MISSOURI DEPARTMENT OF CONSERVATION

AQUATIC NUISANCE SPECIES

MANAGEMENT PLAN

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Executive Summary

Missouri's landscape includes a wide array of aquatic resources: 17 large reservoirs totaling more than 250,000 surface acres; approximately 500,000 smaller public and private lakes and ponds; approximately 17,000 miles of permanently flowing streams and rivers from the smallest wading stream to the mighty Missouri and Mississippi rivers; and another 39,000 miles of intermittent headwater streams. These resources are threatened by migration of non-native aquatic species into open-ended river systems, and by their accidental or intentional release into other public and private waters. The biological and socio-economic effect of each of these introduced species has not yet been fully determined, however, some are known to be significant.

An estimated 50,000 species have been introduced into the United States in the past 200 years. Many, like corn, wheat, rice, other crops, and cattle, poultry, and other livestock, provide more than 98% of our food and can be valued at approximately $800 billion annually. Nationally, however, the damage from other non-native species, and the cost of their control, has been estimated at $138 billion annually (Pimental et al. 2000). These funds dedicated to the prevention, control, and mitigation of the effects of invasive species could have been used for other purposes. When funding from fish and wildlife agency budgets is assigned to the prevention, control, and management of invasive species, important research and management of native ecosystems suffers from the diversion. Public recreational benefits also suffer.

Not every non-native species in Missouri waters qualifies as an Aquatic Nuisance Species (ANS). For the purposes of this plan, aquatic nuisance species are defined as follows:

"Aquatic nuisance species" (ANS) - non-native species which threaten the diversity or abundance of native aquatic species or the ecological stability of infected waters, or commercial, agricultural, aquacultural, or recreational activities dependent on such waters.

Twelve (12) ANS are already found in Missouri waters and 14 additional ANS may arrive in the near future. In many cases, these species are actively expanding their ranges and compounding their effects on native ecosystems. The connection between the Great Lakes and the Missouri and Mississippi rivers via the Illinois River is particularly troubling. States in the Midwest, including Missouri, are concerned about international-sourced non-native ANS from the Great Lakes. In turn, Great Lakes states are concerned about species which have invaded the Mississippi and Illinois rivers and are threatening the lakes as a result of releases from aquaculture and research facilities in the lower Midwest and the south. Finally, even aquatic species that are native within the political boundaries of Missouri can also become aquatic nuisance species if they are moved into drainages where they are not native. Such "inter-basin" transfers of species can be just as damaging to native ecosystems as introductions of species from other continents.

Failure to address the spread and effects of aquatic nuisance species poses grave economic consequences to Missouri. At risk are entire ecosystems and the benefits they provide. Fishing alone accounts for approximately $758 million in total expenditures each year, and ANS directly threaten this and other vital economic activity.

Missouri's ANS Management Plan is designed to meet the requirements of Section 1204 (a) of the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990 as reauthorized and amended by the National Invasive Species Act (NISA) of 1996. The Plan will provide a framework for how future efforts regarding prevention, control, and mitigation of the effects of ANS in Missouri can be organized. It is designed to address ANS invasions at several different stages including:

- identification and implementation of all possible actions necessary to stop the introduction of new ANS from any area outside Missouri,
- development of methodologies to detect and to stop the spread of ANS into new habitats within Missouri,
- minimization of the effects of ANS on native biological communities where introductions have already occurred, and the
- abatement of socio-economic and public health concerns that might arise as a result of ANS.

Missouri's ANS Management Plan includes five Goals under which our objectives and tasks are organized. Taken together, they outline a course of action to address the three stages of ANS invasion listed immediately above. The Goals are:

Goal I: Inform business and community stakeholders and the general public about aquatic nuisance species, and enlist their participation in halting the introduction and spread of aquatic nuisance species.

Goal II: Collaborate in the development and enforcement of state and national legislation and other regulations designed to prevent aquatic nuisance species introduction into state waters.

Goal III: Monitor the occurrence and distribution of ANS in Missouri waters and conduct research into ways to restrict their spread.

Goal IV: Develop and implement techniques and management actions to abate the harmful effects of ANS on native biological communities.

Goal V: Where economically and biologically feasible, abate harmful effects of aquatic nuisance species on socio-economic status and health of Missourians.

Missouri recognizes that successful accomplishment of these goals will require close coordination with other state, regional, and federal jurisdictions, and local governments. Further, ANS management actions must be based on sound science and implemented in an environmentally-aware and conscientious manner.

The “Implementation Schedule” (Appendix E) portion of this Plan is a template for seeking federal grants to implement actions which will prevent the invasion or spread of ANS and the socio-economic and public health concerns which are sure to follow. We will also seek funding for efforts directed at minimizing ANS effects on native ecosystems.

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Introduction

National ANS Status

The introduction of non-native aquatic nuisance species (ANS) into public and private waters of the United States (US) has been a problem since the 1800's. Biologists have expressed concern about these introductions for many years. Recent introductions (zebra mussel, round goby, Asian carp, etc.), however, have brought this problem into prominence in public policy and the management of public lands and water. For the purposes of this plan, *a* ***non-native aquatic species is defined as any species or other viable biological material that enters an ecosystem outside its historic range.*** Non-native aquatic species include those species considered "Aquatic Nuisance Species" which are defined as:

> ***"Aquatic nuisance species" (ANS)*** **- non-native species which threaten the diversity or abundance of native aquatic species or the ecological stability of infected waters, or commercial, agricultural, aquacultural, or recreational activities dependent on such waters.**

Attention and concern has focused on ANS because their introduction and establishment can disrupt the native ecosystem by altering the composition, density, and interactions of native species. Such disruptions often result in significant ecosystem changes including alterations to food webs, changes in nutrient dynamics, and profound reductions in biodiversity.

An alarming number of non-native aquatic species have become established in the US. They include:

- 84 species of mollusks (OTA 1993), and
- 138 species of fish (Courtenay et al.1991, and Courtenay 1993 and 1997).

Currently, 182 non-native species have been identified in the Great Lakes (Ricciardi, A. 2006). These invasive species include: approximately, 59 plants; 25 fishes; 24 types of algae; 14 mollusks; 7 oligochaetes; and several other assorted species.

Nationally, these introductions have had a number of undesirable consequences. Non-native species introductions have contributed to 48 native fish species being classed as threatened or endangered and an additional 27 native fish species have been negatively effected (Wilcove and Bean 1994; Warren and Burr 1994; Aquatic Nuisance Task Force 1994).

Missouri ANS Status

ANS pose a real and significant threat to the aquatic resources and economy of Missouri. Our central geographic location, extensive network of interstate waterways including a connection with the Great Lakes via the Illinois River, and many thousands of acres of public and private ponds and lakes make the likelihood of non-native species introductions greater than for most other inland states. Currently, there are many non-native aquatic species known to occur in Missouri, or are anticipated to arrive in the next few years (Appendix C and D). Twenty-one (21) of these species have been identified as ANS.

Resident ANS –Currently, there are twelve (12) aquatic species that are not native to Missouri that are considered ANS They are:

- **Eurasian watermilfoil:** This adaptable plant was introduced into the US in the Washington D.C. area in 1942. It spread rapidly when fragments of it were transported on boats and boat trailers to new waters. The thick growths formed by this plant are responsible for negative effects to fishing, boating, and water skiing. Its dense surface canopy shades-out native plants and makes it impossible to manage fish populations. Watermilfoil does provide cover for fish early in its establishment period. Its prolific growth, however, often makes it a nuisance. In Missouri, it tends to overpopulate, then disappear in large reservoirs.

- **Purple loosestrife:** This Eurasian wetland plant is believed to have been introduced to the east coast of the US in the 1700-1800's. It currently can be found in 42 states. Once introduced, it quickly spreads, crowds-out native grasses and sedges, and results in a purple monoculture. Ducks, geese, rails, bitterns, frogs, toads, turtles, and other wetland species find it unsuitable for food, cover, or nesting habitat. The spread of purple loosestrife has been assisted by private landowners who enjoyed its brightly colored summer plumes. Nationally, management costs (spraying) and lost forage values are estimated at $45 million annually.

  Purple loosestrife was discovered in Missouri in 1952. It has spread from the initial two counties in which it was discovered and can now be found at 45 sites in 23 counties. It is becoming common along the Missouri and Mississippi rivers and the Bootheel. To date, Greene and Howell counties are the only Ozark counties with purple loosestrife. The largest concentration of loosestrife plants is in the vicinity of La Plata in Macon County where it was first discovered in 1952. The Missouri Legislature declared purple loosestrife a "noxious weed" in 1989. This made it illegal to distribute, sell, or transplant the plant and its seeds anywhere within the state. However, only one variety of purple loosestrife was banned and other nearly identical cultivars are still permitted. Even though these cultivars are not known to be invasive, their similarity makes it difficult to enforce the ban on invasive purple loosestrife.

The Department has been actively engaged in eradication of purple loosestrife on public lands since the late 1980's. Current management efforts include herbicide application on infested public lands in mid-summer prior to seed production. Such treatments must be repeated annually until the residual seed bank has been exhausted and none are left to germinate. Treatment of loosestrife on private property requires continuing landowner permission. Unfortunately, some landowners still enjoy the brightly colored loosestrife and don't consider it to be a problem. Such persistent populations on private property soon spread into nearby natural wetlands. The Missouri Department of Conservation spends approximately $34,000 on purple loosestrife control annually.

- **Dotted duckweed:** The exact origin of this species is not clear, but it is known from at least two locations in Missouri. It is similar in appearance to native duckweeds and flourishes in similar habitats, but is said to rapidly colonize and develop dense, pure stands. Its spread may be limited by an apparent inability to withstand severe cold.

- **Brittle naiad:** A native of Europe and Asia, this species was introduced into the eastern US in 1936. It grows into dense stands that can interfere with fishing and other water recreation. As the name implies, plants become brittle in late summer and this fragmentation, along with seed production, permits brittle naiad to spread rapidly. Dense stands in small impoundments are suspected of contributing to predator-prey imbalance by providing excessive cover for small fish. Brittle naiad can be spread through transport on fishing and boating equipment.

- ***Daphnia lumholtzi:*** This large, non native cladoceran was first discovered in Missouri in plankton samples collected from Pomme de Terre and Stockton lakes in 1990 (Havel et al. 1995). Given habitat suitability, it is no surprise that it has expanded rapidly and established significant populations in many other large lakes such as Table Rock, Taneycomo, and Bull Shoals. Little information is available about the effects of this species on native zooplankton populations, or on the larval fish which use the zooplankton for food. One study (Kolar and Wahl 1998), however, suggests that its size and shape limits predation by larval and very small fish. This would give it a competitive advantage over other zooplankton (i.e., no predators).

- **Zebra mussel:** This is the most infamous ANS introduced to waters of the US in recent years. It was first noted in the Great Lakes following its likely discharge with ballast water from European shipping (Benson and Boydston 1995). It is a very prolific and opportunistic mollusk. When present in large numbers its populations filter significant volumes of phytoplankton and zooplankton from the water column. In some locations zebra mussel densities have reached 700,000 individuals/m^2. Most likely, this has resulted in reduced food availability for native

fish and mussels. Worse, many substrates used by native mussels have been covered by a 3-6 inches (7.6-15.2 cm) mat of zebra mussels (Benson and Boydston 1995; Keniry and Marsden 1995). In addition to these serious alterations to native aquatic ecosystems, zebra mussels also have significant economic effects. They cause an estimated $200 million annually in maintenance costs by clogging intake pipes and screens at domestic water treatment facilities and at industrial plants with direct water intake and treatment facilities (Khalanski 1997). Motors on commercial and recreational watercraft are also vulnerable to the effects of zebra mussels. Their razor sharp shells, when found on public and private beach areas, pose a significant safety hazard.

Zebra mussels were first discovered in Missouri in September 1991 at the Melvin Price Locks and Dam (Pool 26) on the Mississippi River just north of St. Louis. In November 1991, they were found approximately 150 miles (242 km) downstream at Cape Girardeau. In the late 1990's, one individual zebra mussel was found in the Meramec River, though no others have been found there to date.

Currently, zebra mussels can be found in a number of locations in the Missouri and Mississippi rivers with a recent (June 2006) discovery at Lake of the Ozarks in Camden County, Missouri. Zebra mussels are highly invasive and threaten to spread throughout our connecting waterways and our 17 large reservoirs. In response to the spread of zebra mussels, the Department of Conservation has posted and maintained "alert" posters at many public lake and river access sites. In addition, the Department has produced zebra mussel identification (ID) cards and brochures about their biological and economic threats. Currently, posters, ID cards, and brochures about zebra mussels are available at no cost to interested parties who write to "Zebra Mussel", Missouri Department of Conservation, PO Box 180, Jefferson City, MO 65102-0180 or on the Department website at: http://www.mdc.state.mo.us/nathis/exotic/zebra/

- **Asian clam:** The Asian clam (*Corbicula*) is a freshwater species whose home range includes southern and eastern Asia and Africa. It was introduced to the western U.S. in the 1930's but has since spread throughout much of the country. They can reach densities of up to 2,000 individuals/m^2. Because they can reach such high densities, Asian clams are potentially direct competitors with native mussel species and can foul utility intake pipes. They are also subject to periodic die-offs that temporarily reduce densities, but the subsequent decomposition of their remains can degrade water quality.

- **Common carp:** A native of Asia, the common carp was introduced centuries ago into Europe and to the U.S. as early as 1831. The first introduction to Missouri was in 1879. The Missouri Fish Commission reared and stocked carp in public and private waters until 1895 when they were already widely established throughout the state. Common carp are an adaptable species and are one of the

most widespread fishes in Missouri (Pflieger 1997). They are omnivorous, feeding on both plant and animal matter, but most studies indicate that aquatic insects are the most important item in their diet. They can become so abundant in some habitats that they are suspected of displacing other, more desirable, species of fish or of damaging aquatic vegetation by actively feeding along the substrate. Common carp can present a sport fishing opportunity in waters where few others exist, but their propensity for overpopulation, displacement of other species and potential damage to aquatic habitat are reasons to classify them as aquatic nuisance species

- **Grass carp:** This Asian carp was introduced to the US in 1963 by Auburn University and the US Fish and Wildlife Service. Despite repeated warnings and attempts to limit its spread, it can now be found in 48 of the 50 states. As adults, grass carp eat large amounts of native and non-native aquatic plants, but they have proved difficult to control. Too frequently the number of fish stocked exceeds the number needed to achieve aquatic plant control thereby leading to the elimination of all aquatic plants, including desirable native species. Due to continuing legal, widespread stocking by private landowners, grass carp are common throughout Missouri. Biologists are now attempting to re-establish aquatic vegetation in impoundments where it has been eliminated by grass carp.

- **Bighead carp:** This Asian carp was introduced to the US for use as a planktivore in sewage lagoons and in ponds used for the culture of catfish. Following its escape, it established reproducing populations in the middle and lower Missouri and Mississippi river systems. Bighead carp are effective planktivores that have the potential to seriously deplete zooplankton populations when present in large numbers. Significant effects to populations of native planktivores such as paddlefish (*Polydon spathula*), bigmouth buffalo (*Ictiobus ciprinellus*), gizzard shad (*Dorosoma cepedianum*), and larval fish of many species may occur. The bighead is already widely spread throughout the Missouri and Mississippi rivers and Lake of the Ozarks and major un-impounded tributaries.

- **Silver carp:** The silver carp is an Asian carp which was imported to Arkansas in 1973 for phytoplankton control in eutrophic waters commonly encountered in commercial catfish production facilities. It has the potential to directly compete with larval fish and native mussels for food, but its long-term effect on native ecosystems is not currently known. The silver carp often leaps from the water when disturbed. Anglers, boaters, and water skiers have been injured by these jumping fish. Such interactions are common on Missouri waters and constitute a truly significant threat to public safety. The silver carp is common throughout the Missouri and Mississippi rivers.

- **White perch:** This smallish 7-9 inch (18-23 cm), silvery-white, spiny fish is an import from the east coast of the US and from the Great Lakes via the Illinois River. Like the white bass, it is a schooling fish which feeds on plankton, aquatic

insects, crayfish, and small fish. Currently, it can be found in the Missouri river and some adjacent oxbow lakes. It matures and is capable of reproducing at one year of age. Each female produces as many as 150,000 eggs per spawn. In reservoirs and natural lakes like the oxbows of northwest Missouri and in small rivers, the white perch rapidly alters the ecological balance and displaces native fishes. Once it becomes the dominant fish in an area, it soon begins to show evidence of slower growth and stunting.

ANS Threats – Fourteen (14) other species which are not currently found in Missouri waters have been categorized as ANS. They are, however, threatening invasion. If successful, they will pose serious threats to native ecosystems. ANS currently threatening to invade Missouri waters are:

- **Water hyacinth:** This warm water non-native plant was introduced to the US in the 1880's. It reproduces both sexually and asexually and its seeds are commercially available nation-wide. If it develops tolerance to Missouri winters, it will develop dense populations in our many streams, rivers, ponds, and lakes and prove impossible to control at reasonable expense. Currently, it is restricted to small populations in southeast Missouri due to limited cold weather tolerance.

- **Hydrilla:** This plant native to Asia, Africa, and Australia was brought to the US by the aquarium industry in the early 1950's. It was first identified in Florida waters, and from there it spread rapidly throughout the nation. Once *Hydrilla* is established, it is nearly impossible to eradicate. Like Eurasian watermilfoil, it forms dense mats of plants at the water surface which reduces the diversity of native plants and other aquatic life, clogs waterways, and interferes with aquatic recreation. Dense growths of *Hydrilla* are common in areas of high nutrient run-off or discharge. *Hydrilla* has been collected in Tennessee and Arkansas and represents a serious threat if it is introduced to Missouri waters.

- **New Zealand mudsnail:** This small snail reproduces asexually and has become common in many trout streams on the western slopes of the Rocky Mountains and the headwaters of the Missouri River. In 2004 it was found on the eastern slope of the Rocky Mountains in Colorado. It soon becomes the dominant invertebrate in new habitats, sometimes reaching densities of 800,000 individuals/m^2 which consume up to 75% of a stream's primary productivity. The mudsnail is readily transported from one water body to another in mud or vegetation on fishing and boating equipment. Once in new habitats, it rapidly alters food webs and appears to be responsible for the decline of local fisheries. It poses a serious threat to Missouri's Ozark streams and potentially trout and smallmouth bass fisheries.

- **Rusty crayfish:** This native of the Ohio River basin has the potential to seriously affect native crayfish populations. It has been introduced to new waters by anglers who used them for bait and subsequently released unused crayfish. Crayfish from these "bait bucket" introductions rapidly colonized new waters.

The rusty crayfish is very aggressive and has replaced native species in northern Wisconsin lakes. It feeds on a variety of aquatic plants, benthic invertebrates, woody detritus, fish eggs, and small fish. Rusty crayfish consume approximately twice as much food as do similar size, native, northern crayfish (*Orconectes virilis)* because of their higher metabolic rate. Other studies have shown that the rusty crayfish is capable of reducing aquatic plant density and species diversity, thereby dramatically altering the functioning of aquatic ecosystems. Behaviorally, the aggressiveness of the rusty crayfish is manifested by its "claws-up" defensive posture which reduces its susceptibility to predation by fish. Its size and aggressive nature allow it to out-compete native species for food and cover. Currently, no populations of rusty crayfish are known to exist in Missouri, but it was found in a 2003 survey of Missouri bait shops and its potential introduction via bait bucket stocking is a serious threat to native crayfish populations and ultimately, Ozark sport fish that rely on crayfish for food.

- **Quagga mussel**: The quagga mussel is an introduced mollusk species closely related to the zebra mussel. It has wider habitat tolerances, is able to colonize the brackish water of estuaries, and reproduces successfully at colder temperatures than the zebra mussel. In the Great Lakes, the quagga appears to be displacing the zebra mussel on soft substrates in deep water. The quagga also attaches to hard surfaces and, like the zebra mussel, has bio-fouling potential. It was introduced to the Great Lakes in about 1989 and has become well-established in Lake Erie. A single quagga mussel was collected in the upper Mississippi river above St. Louis in 2002.

- **Northern snakehead:** This Asian import is a voracious feeder which has been collected in many states, including Arkansas. It has established breeding populations in the Potomac River basin of Virginia and Maryland. All other specimens captured in the wild are thought to be individual fish released from aquaria. The snakehead has also been observed in live fish markets catering to Asian consumers. Since it is an obligate air breather, the snakehead can readily survive both transport and fish market conditions. Snakeheads can spawn up to five times per year and both parents guard the nest. The snakehead has the potential to pose serious problems to native fish populations, if introduced to Missouri waters.

- **Black carp:** The black carp is the latest Asian carp of concern in Missouri and the southeastern US. Black carp are currently being held at a number of aquaculture facilities in the lower Mississippi River basin. An undetermined number of fish were reported to have entered the Osage River (Missouri) from an aquaculture facility during the 1993 floods. Mississippi River (Pool 25) commercial fishermen recently reported harvesting black carp, but harvest of individual fish has only been reported at 3 sites throughout the Mississippi River basin. Triploid black carp are currently being held at a number of aquaculture facilities in Missouri under a Missouri Conservation Commission approved plan. The main concern with black carp centers on their primary food source - snails

and mussels. The effects of black carp are potentially devastating to Missouri's native mussel fauna – including threatened and endangered species - and sport fish populations.

- **Ruffe:** A native of Europe and western and central Asia, the Eurasian ruffe was likely introduced to Lake Superior in ballast water discharges from transoceanic shipping in 1986 and has since spread to lakes Huron and Michigan. The ruffe is a small, spiny fish, rarely exceeding six inches (15 cm) in length. It is an aggressive relative of the yellow perch and is largely immune to predation because of its spines. The ruffe may reach sexual maturity in one year, may spawn up to six times per year, can produce 6,000-200,000 eggs per spawn and live up to 11 years. It feeds on a variety of invertebrates as well as fish eggs, larvae and young. It is found in a wide variety of aquatic habitats and is tolerant of poor water quality. The most likely route for the ruffe to reach Missouri is through the Chicago Sanitary and Ship Canal to the Mississippi River.

- **Round goby:** This aggressive fish was introduced to the Great Lakes in 1990 with the discharge of ballast water into the St. Clair River near Detroit by European vessels. It is very tolerant of poor water quality, has the ability to rapidly expand its range, and currently can be found in the upper Great Lakes and the Illinois River. From the Illinois River, it has unrestricted access to the entire Mississippi and Missouri river drainages. The round goby feeds voraciously on native benthic fish such as darters and sculpins, fish eggs, and benthic macroinvertebrates.

- **Viral hemorrhagic septicemia (VHS):** VHS is a deadly fish virus and an pathogen that is threatening fish in several states surrounding the Great Lakes. VHS was diagnosed for the first time in the Great Lakes as the cause of large fish kills in lakes Huron, St. Clair, Erie, Ontario, and the St. Lawrence River in 2005 and 2006. Thousands of muskies, walleye, lake whitefish, freshwater drum, yellow perch, gizzard shad, redhorse and round gobies died. Many Chinook salmon, white bass, emerald shiners, smallmouth bass, bluegill, black crappie, burbot, and northern pike were diseased but did not die in large numbers

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- **Whirling disease:** Whirling disease, a potentially lethal infection of salmonid fish, is caused by the myxozoan parasite, *Myxobolus cerebralis*. This Eurasian disease, first observed in North America in the 1950's, is a good example of how an invasive microbial species can cause serious environmental and economic impacts. Rainbow trout are particularly susceptible.

- **Didymo:** Didymo is a freshwater microscopic diatom. It is found in streams and rivers in much of North America. Didymo increasingly poses a threat to aquatic ecosystems because it forms extensive mats on stream beds. Didymo attaches to the streambed by stalks, which have a rough texture similar to wet wool.

- **Spiny and fishhook water fleas:** Both water fleas entered the Great Lakes in ship ballast water from Europe. The spiny water flea arrived in the 1980s, followed in the 1990s by the fishhook water flea. Only about ¼ to ½ inches in length, individual water fleas may go unnoticed. However, both species tend to gather in masses on fishing lines and downrigger cables, so anglers may be the first to discover a new infestation. These water fleas are predators. They eat smaller zooplankton, including Daphnia. This puts them in direct competition with juvenile fish for food.

Conclusion - Failure to invest in ANS research, prevention, and control has a high price tag both financially and biologically. Aquatic recreation and tourism, including boating, fishing, canoeing, etc. are an integral part of Missouri's economy. Collectively, these activities have a net value of several billion dollars per year and support many thousands of jobs. Fishing alone accounts for approximately $758 million in total expenditures annually (US Fish & Wildlife Service 2003). ANS, however, are a continuing threat to the viability of this element of Missouri's economy. Public awareness of the problems caused by ANS is growing, but the solutions are not yet readily apparent.

They also have the potential to directly affect public and private economies locally, at the state level, and nationally. However, the direct and indirect costs associated with the control, eradication, or management of ANS are not well known. Research into these realms of knowledge is currently focused on the most abundant and widespread species (e.g. zebra mussels and purple loosestrife). Unfortunately, control costs are expected to be very high. For example, research into the life history of the sea lamprey and the implementation of efforts to control it in the Great Lakes costs approximately $14 million per year (Office of Technology Assessment 1993).

The plants and animals highlighted above are serious threats to Missouri's native aquatic resources and have been identified as ANS. Appendix E includes detailed "species accounts" for the 26 ANS found in, or threatening, Missouri. This comprehensive management plan for selected non-native species, identified as ANS, is our first attempt at identifying and developing management strategies to stop the spread and limit the effects of ANS which have already invaded (or which may invade) the public and private waters of Missouri.

Existing Authorities and Programs

Many biological and economic effects posed by ANS require coordinated and comprehensive policies and programs that address both the spread and control by all levels of government and the private sector. Some of the policies and programs must be new. Others are already in place. Both will need to be more effectively focused on the problems if we are to achieve more positive results.

Federal Role

The principal federal policy dealing with ANS was established by the enactment of the Non-native Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA, PL 101-646). This law provides guidance for the development of each state's ANS management plan. Upon federal approval of the state plan, federal funding to implement key elements of it may be made available. Specifically, the objectives of NANPCA are:

- To prevent further unintentional introductions of ANS,

- To coordinate federally-funded research, control efforts, and information dissemination,

- To develop and carry out environmentally-sound control measures to prevent, monitor, and control unintentional introductions,

- To understand and minimize economic and ecological damage, and

- To establish a program of research and technology development to assist state governments.

NANPCA was enacted partially as a response to the invasion of the Great Lakes by the zebra mussel which caused many ecological and socio-economic effects. It clearly, however, was also directed at limiting future unintentional introductions of ANS and the dispersal of ANS already within public and private waters of the US. The Act established a national ANS Task Force which is jointly chaired by the USFWS and the National Oceanic and Atmospheric Administration (NOAA). The Task Force consists of members representing ten federal agencies and 12 ex-officio members representing non-federal governmental agencies. The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA), reauthorized in the National Invasive Species Act of 1996 (NISA), established the ANSTF to coordinate ANS activities among federal agencies and between federal agencies, regional, state, tribal, and local organizations.

The ANSTF has five standing committees, each focused on an essential aspect of the ANS Program.

- Prevention
- Detection and Monitoring
- Control
- Research
- Communication, Education, and Outreach

The ANS Task Force encourages state and interstate planning entities to develop management plans describing detection and monitoring efforts of aquatic nuisance species, prevention efforts to stop their introduction and spread, and control efforts to reduce their impacts. Management plan approval by the Aquatic Nuisance Species Task Force is required to obtain funding under Section 1204 of the Aquatic Nuisance

Species Prevention and Control Act. Regardless of financial incentives, plans are a valuable and effective tool for identifying and addressing ANS problems and concerns in a climate of many jurisdictions and other interested entities.

The USFWS enforces the Lacey Act which prohibits importation and interstate delivery of listed species. The list of injurious live or dead fishes, mollusks, crustaceans, or their eggs (50 CFR 16.13) includes the following ANS of potential interest to Missouri:

- Walking catfish (family Clariidae)
- Mitten crabs (genus *Eriocheir*)
- Zebra mussels (*Dreissena polymorpha*)
- Live or dead salmonids and their live fertilized eggs or gametes unless certified free of *Oncorhynchus masou* virus and viruses causing viral hemorrhagic septicemia and infectious hematopoietic necrosis
- Snakehead (genus *Channa* or *Parachanna*)
- Silver Carp (Hypophthalmichthys molitrix)
- Largescale Silver Carp (Hypophthalmichthys harmandi)

The US Department of Agriculture regulates the importation and interstate transport of aquatic pests and pathogens that are capable of negatively affecting crop production, horticulture, silviculture, and aquaculture. The Plant Protection Act of 2000 (Title IV of PL 106-224) established a federal noxious weed list which included 19 aquatic or wetland species. Included among the 19 was *Hydrilla verticillata*, a species of primary concern in Missouri.

The US Environmental Protection Agency (EPA) is responsible for administering the National Pollution Discharge Elimination System (NPDES) of the Clean Water Act. The application of pesticides to waters of the US to control ANS ordinarily would require a NPDES permit. Fortunately, “Interim Guidance” offered by the EPA as a result of litigation considers application of pesticides for the control of ANS in waters of the US not to constitute the discharge of a pollutant, and therefore does not require possession of an NPDES permit.

Regional Role

Fisheries-related interstate policy and activities within the Mississippi River Basin have been regionally coordinated by the Mississippi Interstate Cooperative Resource Association (MICRA). Missouri has been an active participant and supporter of MICRA since its establishment in 1991. No change in this involvement is anticipated. In addition, Missouri has recently become a member of the newly-established Southeast Aquatic Resource Partnership (SARP).

The national ANS Task Force has established a number of regional panels among which responsibility for developing and implementing viable ANS policy has been assigned. Missouri is covered by the Mississippi River Basin Regional Panel (MRBRP).

Presumably, approval of this plan by the national ANS Task Force will benefit from a favorable review and approval by the MRBRP.

Missouri has only one point of contact with the Great Lakes-the Illinois River. Currently, Missouri does not participate in the Great Lakes Regional Panel (GLRP). Other states, federal and interstate commissions, international, and private interests are better able to develop and implement ANS policy and management within that particular sphere of interest. Missouri has no plan to seek representation on the GLRP. Any inputs regarding ANS of mutual concern to both panels will be made through the MRBRP.

State Roles

Historically, the control, management, protection, and restoration of non-migratory fish and wildlife are vested in the states. All states have, in light of that responsibility, enacted legislation and rules governing how and when fish and wildlife might be taken, transported, and stocked in areas under their jurisdiction. Many ANS have been "regulated" by a variety of state legislated actions and administrative rules. The introduction and spread of non-native plants have also been regulated by states, particularly when damage to crops is suspected. Funding for actions taken to enforce state ANS legislation and administrative rules has been provided by the states through their internal budgetary processes.

NANPCA established a state-federal interface for joint efforts in the control of ANS. Section 1204 of that law deals with the development of comprehensive state ANS management plans. Such plans must "identify those areas or activities within the state, other than those related to public facilities, for which technical and financial assistance is needed to eliminate or reduce the environmental, public health, and safety risks associated with ANS." Further, the plans should identify feasible, cost-effective, and environmentally sound ANS management strategies and actions which might be undertaken by local and state governments, agencies, and organizations. Following public and private input and completion of the state comprehensive ANS management plan, it is submitted to the national ANS Task Force. The state becomes eligible for federal cost-share funding of actions identified in the plan following its approval.

Missouri's Authorities and Programs

The prevention and control of ANS in Missouri is primarily the responsibility of a constitutionally established, bipartisan, four-member Conservation Commission which was created in 1937. In turn, the Commission established the Department of Conservation, an agency funded by the sale of hunting, fishing and trapping permits and, since 1976, a voter-approved constitutional amendment that created a 1/8% state sales tax earmarked for the Department. The *Wildlife Code of Missouri* contains the rules and regulations of the Conservation Commission (and certain statutes not inconsistent with those rules and regulations). The *Wildlife Code* regulates how, when, and in what numbers persons may buy, sell, transport, and possess species for their private enjoyment, or the purposes of aquaculture. It also establishes a Prohibited

Species List (Appendix A) and an Approved Aquatic Species List (Appendix B). ANS are not included on the approved list of aquatic species unless they are already "well established." The accidental or intentional introduction of new ANS to waters of the state is prohibited and categorized as a Class A misdemeanor.

The Missouri Legislature added purple loosestrife (*Lythrum salicaria*) to the Missouri Department of Agriculture's list of "noxious weeds" (http://www.moga.mo.gov/statutes/chapters/chap263.htm) in 1989 and spotted knapweed (Centaurea stoebe micranthos) in 2008. These actions made it illegal to distribute, sell, and transport the plants and their seeds anywhere in Missouri. Enforcement of the provisions of this act is vested in the Department of Agriculture (a difficult task given the nearly identical appearance of un-banned varieties of purple loosestrife).

In their past two sessions the Missouri Legislature failed to enact a bill which would have created an Invasive Species Advisory Committee. The committee, as envisioned, would:

- advise state agencies regarding the prevention and control of invasive species,
- facilitate development of a coordinated network among state agencies to document, evaluate, and monitor effects from invasive species on the economy, the environment, and human health,
- share information on a local, state, and national level and facilitate access to distribution and levels of invasive species, and
- prepare and release a biennial state invasive species report in even numbered years.

The Missouri Department of Conservation has hired an Invasive Species Coordinator to lead a multi-divisional work group to address invasive species issues, propose actions to address those issues and develop and implement an Invasive Species Action Plan. The coordinator will also lead implementation of the Aquatic Nuisance Species Management Plan.

Management Actions

The Missouri ANS Management Plan addresses three stages of invasion:

- the introduction of new ANS into the Missouri and Mississippi rivers and inland waters of the state; the

- spread of established ANS populations into previously un-infested areas; and

- abatement of harmful ecological, economic, social, and health effects resulting from the introduction and spread of ANS.

Missouri's ANS Management Plan includes five Goals under which our objectives and tasks are organized. Taken together, they outline a course of action to address the three stages of ANS invasion listed immediately above. The Goals are:

Goal I: **Inform business and community stakeholders and the general public about aquatic nuisance species, and enlist their participation in halting the introduction and spread of aquatic nuisance species.**

Goal II: **Collaborate in the development and enforcement of state and national legislation and other regulations designed to prevent aquatic nuisance species introduction into state waters.**

Goal III: **Monitor the occurrence and distribution of ANS in Missouri waters and conduct research into ways to restrict their spread.**

Goal IV: **Develop and implement techniques and management actions to abate the harmful effects of ANS on native biological communities.**

Goal V: **Where economically and biologically feasible, abate harmful effects of aquatic nuisance species on socio-economic status and health of Missourians.**

Missouri recognizes that successful accomplishment of these goals will require close coordination with other state, regional, and federal jurisdictions, and local governments. Further, ANS management actions must be based on sound science and implemented in an environmentally-aware and conscientious manner.

Goals, Objectives, and Tasks

Goal I: **Inform business and community stakeholders and the general public about aquatic nuisance species, and enlist their participation in halting the introduction and spread of aquatic nuisance species.**

Justification: The best way of halting the introduction and spread of many ANS is by informing target audiences about the dangers ANS pose to native species, and about the expenses we may face to manage and control ANS. Public concern and involvement have been critical in the effort to keep zebra mussels out of Missouri's major impoundments. Informational signage at public accesses informs boaters of the dangers posed by zebra mussels, and of how to prevent their spread. Brochures and TV segments about the threats posed to native ecosystems, and to public and private property, are available. These informational efforts must be continued, expanded, and applied to other ANS.

Potentially, ANS can be introduced to Missouri and spread by a variety of pathways including:

- inadvertently
  - bait bucket discards (e.g., rusty crayfish),
  - releases from aquaria (e.g., snakehead fish),
  - being carried on boats, waders or other recreational equipment (e.g., zebra mussels, Eurasian watermilfoil),
- accidentally
  - escapes from aquaculture facilities (e.g., black and bighead carp),
- deliberately
  - intentional stockings (e.g. grass carp), and
- naturally
  - range expansion (e.g., round goby),
  - airborne and waterborne seeding (e.g., purple loosestrife).

An active public information program could reduce inadvertent bait bucket introductions, releases from aquariums, and import of ANS on fishing and boating equipment.

Objective IA. Raise public awareness of ANS issues in general, and generate widespread public support for efforts to prevent, control, and eradicate ANS.

Task IA1. Post the Missouri ANS Management Plan on the MDC public web page.

Task IA2. Create and post on the MDC public web page well-illustrated and informative pages about ANS, their threats to Missouri's native ecosystems, their threats to socio-economic well being and public health, and what people can do to prevent their spread.

Task IA3. Link the MDC public web page (and ANS information) to regional and national web pages dealing with ANS control and management.

Task IA4. Link the Missouri Department of Agriculture web page dealing with noxious weeds to the MDC public web page and ANS information.

Task IA5. Publish two articles annually on ANS and their threats to Missouri's ecosystems in the *Missouri Conservationist* magazine.

Task IA6. Present two segments annually about ANS and their threats to Missouri's ecosystems on *Missouri Outdoors*.

Task 1A7. Include information about ANS in exhibits for use at Nature Centers and portable displays for use at other public events.

Task IA8. Include information on ANS threats, possible remedial actions, and the importance of unaltered native ecosystems in MDC K-12 educational programs and materials.

Task IA9. Include information about the general prohibition against stocking fish to the wild on signs posted at public access and lake areas, to *Fishing Prospects*, and to other widely disseminated publications.

Objective IB. Target stakeholders, including state and federal partners, Stream Teams, commercial and recreational anglers, recreational boaters, shipping/barge industry groups, aquaculturists, aquarists, marina owners, and bait shop owners and distributors with informational efforts about the threats posed by ANS. Cultivate their cooperation and participation in management efforts directed at preventing, minimizing or eliminating ANS effects. Informational efforts should emphasize the potential harm to the particular resource of interest to the stakeholder and specific actions the stakeholder can take to minimize ANS effects.

Task IB1. Link the Missouri Stream Teams web page to the MDC public web page about ANS.

Task IB2. Include information on ANS in *Missouri Fishing Prospects*, an annual publication distributed to anglers.

Task IB3. Create informational brochures about ANS for distribution on request at state and regional fairs, nature centers, boat and tackle shows, and public offices.

Task IB4. Create and post signs about ANS at public access facilities and at cooperating public and private marinas.

Task IB5. Provide ANS information to boat owners during the annual boat registration process.

Task IB6. Provide ANS information to boat and canoe dealers/manufacturers for inclusion with each new boat or canoe purchase.

Task IB7. Provide ANS information to bait and bait bucket dealers/manufacturers about the dangers of dumping unused bait. Encourage them to post the warnings prominently in retail locations and to distribute the information to customers.

Task IB8. Prepare and present annual updates about ANS to the annual meeting of the Conservation Federation of Missouri.

Task IB9. Provide opportunities for public input regarding ANS and MDC's efforts to limit the damage of ANS on the people and economic, social and natural resources of Missouri. Invite stakeholder groups to participate in planning and implementation of management efforts.

Objective IC. Inform conservation professionals about ANS and assist them in their efforts to inform stakeholders and the public about ANS.

Task IC1. Provide professional development opportunities for MDC employees about ANS, by presenting information at annual division conferences, and via other means upon request.

Task IC2. Make multi-media resources about ANS available to MDC employees for presentation to the public and to stakeholder groups.

Task IC3. Provide professional development opportunities for employees of the Departments of Natural Resources and of Agriculture, members of the Missouri Aquaculture Association, teachers, and others, about ANS in Missouri.

Task IC4. Evaluate the effectiveness of informational efforts undertaken in Goal I, and use the findings to adjust those efforts.

Objective 1D: Participate in the ANS National Marketing Strategy developed by the Association of Fish and Wildlife Agencies (AFWA).

Task 1D1. Develop Missouri's ANS Marketing Plan with a grant provided by the AFWA.

Task 1D2. Implement the Objectives, Strategies, and Tasks approved in Missouri's ANS Marketing Plan.

Task 1D3. Provide results of evaluation on marketing efforts of the Missouri Aquatic Nuisance Species Plan

Goal II: Collaborate in the development and enforcement of state and national legislation and other regulations designed to prevent aquatic nuisance species introduction into state waters.

Justification: An aid to halting ANS invasions is to provide the regulatory arms of local, state, and national governments with enforceable legislation and administrative regulations. If the public and involved industries have been adequately informed and educated about the multi-faceted threats of ANS (See Goal I, above.), enforcement of pertinent rules and legislation becomes a matter of priority setting and funding. This

would be a continuous and ongoing effort as new potentially invasive, exotic or nuisance species are moving to new areas regularly. Participation in national, regional, and state panels planning the development of legislative action and regulations on ANS, and their enforcement, is important in the creation of who has standing in this important issue.

Objective IIA. Coordinate and develop a comprehensive state legislative and regulatory program aimed at preventing the introduction and spread of ANS into un-infested waters of the state.

Task IIA1. Continually review, and update as necessary, the *Approved Aquatic Species List* to establish a baseline of species which may be safely imported and released into Missouri waters.

Task IIA2. Review existing state laws and rules and make necessary recommendations for changes.

Task IIA3. Participate in Missouri Aquaculture Coordinating Council meetings.

Task IIA4. Elevate the penalty for release of aquatic nuisance species beyond a Class A misdemeanor.

Objective IIB. Participate in the development of a Midwest regional policy directed at preventing new ANS invasions into the Missouri and Mississippi rivers.

Task IIB1. Maintain a presence in MICRA and, if possible, participate in any sub-committees developing policy on, or planning research into, ANS.

Task IIB2. Participate in the Mississippi River Basin Panel of the ANS Task Force.

Task IIB3. Participate in the Southeast Aquatic Resource Partnership ANS Task Force.

Goal III: Monitor the occurrence and distribution of ANS in Missouri waters and conduct research into ways to restrict their spread.

Justification: An essential first step is the establishment of baseline data about the current status of ANS populations. The logical second step is participation in research into ways and means of restricting their spread. Research conducted on ANS must be carefully coordinated with the efforts of other states, industry, and the government.

Objective IIIA. Identify the current distributions of ANS in Missouri waters.

Task IIIA1. Organize and encourage Department field staff, interested volunteers, and other stakeholders to monitor and report the occurrences of ANS. Provide appropriate identification materials for each ANS to be monitored.

Task IIIA2. Update ANS distributions as additional information becomes available throughout the year. Create a spatial database for ANS from which we can develop reports. Prepare a summary report at the end of each fiscal year.

Task IIIA3. Recommend implementation of additional ANS monitoring, or the use of new techniques, particularly to document the presence or spread of new ANS.

Task IIIA4. Development of an early detection/rapid response system and protocol with partners and stakeholders in Missouri.

Objective IIIB. Conduct or support research into ANS including life history studies, habitat use, potential effects on native species, the methods by which they are transported and introduced to new waters and techniques useful for their control or elimination.

Task IIIB1. Conduct a comprehensive review of past and on-going research on ANS and make recommendation for research to be done during the next two 5-year intervals (FY 2008-2012 and FY 2012-2016).

Task IIIB2. Where possible, develop, fund, and implement "action plans" to interrupt pathways by which new ANS are introduced to, and spread among, Missouri waters.

Goal IV. Develop and implement techniques and management actions to abate the harmful effects of ANS on native biological communities.

Justification: ANS can have serious effects on existing biological communities and the underlying ecological processes that control them. Without co-evolved parasites predators and competitors, some ANS out-compete and displace native plant and animal populations. While doing so, the ANS influences food webs, nutrient dynamics, and the biodiversity of the ecosystem. Abatement of these effects requires detailed knowledge of the mechanisms or behaviors which ANS use to insert themselves into native ecosystems. A number of protocols must be followed when designing and implementing abatement strategies.

- The abatement strategy must not create more, or greater, problems than those posed by the ANS,
- It must be well focused and not create serious or long term damage to the environment or untargeted species, and

- It must not reduce the long-term human use of the water body, or threaten human health.

Objective IVA. Develop economically viable abatement plans which meet the protocols discussed below, for ANS which are threatening native biological communities and which meet the protocols discussed above.

Task IVA1. Develop abatement plans for ANS using information from monitoring efforts and national, regional, and state research.

Task IVA2. Maintain or establish an adequate reproducing stock of threatened native organisms that can be used to restock Missouri waters following the elimination or significant reduction of ANS threats, as described in species recovery plans.

Task IVA3. Secure funding from federal, state, other public sources, and from private interests to implement ANS abatement plans.

Goal V: Where economically and biologically feasible, abate harmful effects of ANS on socio-economic status and health of Missourians.

Justification: It is difficult to assess the effects that ANS have on the socio-economic and public health status of Missourians. It is even more difficult to convey information about the costs of these effects to those responsible for making decisions and the general public. Actions proposed for the management and control of ANS effects are frequently impeded by lack of political support or shortfalls in available funding. Too commonly, ANS abatement, an indirect benefit, is measured against expenditures which have direct or immediate benefits to individual humans, and their populations.

Objective VA. Assess the effects of ANS on the socio-economic status and public health of Missourians.

Task VA1. Evaluate the dollar costs and human injury threats associated with invasions by ANS.

Task VA2. Prioritize the development of abatement plans for ANS in cooperation with state and federal interests, affected industries, and the general public. Be sure to adhere to the protocols listed for the development of abatement plans in Goal IV, above.

Objective VB. Develop and implement ANS abatement strategies including physical, chemical, and biological control methods which have a reasonable potential to reduce or eliminate populations of targeted organisms.

Task VB1. Support and conduct scientific research which investigates potential abatement strategies.

Task VB2. Participate in a technology transfer program for the distribution of research findings and results achieved while implementing the various abatement strategies.

Task VB3. Seek approval for, fund, implement and monitor priority abatement plans.

Objective VC. Where feasible, develop strategies to adapt human activities to co-exist with ANS populations when control is impractical, or uneconomic.

Task VC1. Actively seek beneficial uses for ANS and convey them to the general public. For example, information on fishing for grass or bighead carp along with recommendations on bait and recipes could be used to enlist the help of anglers in reducing their populations.

Task VC2. Participate in research into how humans can best co-exist with ANS infestations.

Task VC3. Promote a commercial fishery for Asian carps in existing commercial waters and determine if a commercial fishery for common carp can be developed in impoundments without adverse effects on sport fish populations or sport fishing. In compliance with the Lacey Act, silver carp can not be transported alive.

Program Monitoring and Evaluation

Program monitoring and evaluation is vitally important. It will enable us to determine the effectiveness of objectives and tasks identified in this management plan at stopping the introduction and spread of ANS. The success or failure of abatement measures undertaken to mitigate ecological, socio-economic, and public health concerns will also be followed. Timely oversight of program objectives will permit “mid-course” corrections as additional information becomes available. Monitoring and evaluation of certain program elements has been “built into” several of the above objectives. Overall program progress will involve three components: oversight, evaluation, and dissemination of information.

Oversight: A committee composed of representatives from the public, associated industries, other state agencies, the Governor’s office, and Department staff will be convened to oversee ANS program management issues and progress. The committee will be chaired by a Department Invasive Species Coordinator and should meet, at least, annually.

Evaluation: The committee will need to develop performance measures to assess the effectiveness of management actions. These measures might include: whether or not

objectives are achieved, rate of spread of ANS species or displaced native species (number of miles or acres occupied), changes in abundance of an ANS species and the directly or indirectly affected native species or changes to federal or state threatened or endangered species.

More importantly, the committee must place special emphasis on the acquisition and assignment of funding necessary to meet tasks identified in the plan. Evaluation should also include inputs from interests affected by plan implementation.

Dissemination: The oversight committee will prepare periodic reports highlighting progress toward meeting the plan's goals and objectives. These reports will be made available to the public, and local, state, and federal decision makers.

In their past two sessions the Missouri Legislature failed to enact a bill which would have created an Invasive Species Advisory Committee. The proposed committee would have had representation as identified in "Oversight" above. If this legislation is approved in the future, the Oversight Committee should be replaced by the Invasive Species Advisory Committee. This committee, as envisioned, would have:

- advised state agencies regarding the prevention and control of invasive species,
- facilitated development of a coordinated network among state agencies to document, evaluate, and monitor effects from invasive species on the economy, the environment, and human health,
- shared information on a local, state, and national level and facilitate access to distribution and levels of invasive species, and
- prepare and release a biennial state invasive species report in even numbered years.

Glossary

ANS Task Force: A federal work group established by NANPCA which is jointly chaired by FWS and NOAA charged with coordinating state, federal, international, and private efforts related to ANS.

Aquaculture: The controlled cultivation and harvest of aquatic organisms.

Aquarium industry: Collectively, any entities that breed, grow, import, hold, transport, or sell non native fishes, invertebrates, and plants specifically for display in fresh and salt water aquaria

Aquatic nuisance species (ANS): A non-native species which threatens the diversity or abundance of native aquatic species or the ecological stability of infected waters, or commercial, agricultural, aquacultural, or recreational activities dependant on such waters.

Baitfish: A fish species commonly sold for use as recreational fishing bait (eg., fathead minnow, golden shiner).

Bait industry: Persons who grow, import, hold, transport, and sell bait for use by licensed commercial and recreational anglers. Part of the aquaculture industry.

Injurious species: Species designated by the United States Fish and Wildlife Service in 50 CFR 16.11-16.15.

http://www.fws.gov/contaminants/otherdocuments/injuriouswildlifelist.htm

Non-native Any species that enters an ecosystem outside of its historic range, including organisms transferred from one country to another.

Noxious weed: Any plant which, when established, is highly destructive of, or competitive with, native or desirable plant species and which is difficult to control by cultural or chemical practices.

Persistent toxics: A pollutant that remains in the environment for a substantial period of time and that is potentially harmful to individual organisms and the health of native ecosystems.

Unintentional introduction: The introduction of a non-native species as a result of actions other than its purposeful introduction to public waters by an authorized entity. The classic example is the introduction of the zebra mussel to the Great Lakes in the discharge of ballast water from ocean-going ships.

Waters of Missouri: All rivers, streams, lakes and other bodies of surface water lying within or forming part of the boundaries of the state which are not entirely confined and located completely upon lands owned or leased by a single person or by two (2) or more persons jointly or as tenants in common or by corporate shareholders, and including waters of the United States lying within the state. Waters of the state will include any waters which have been stocked by the state or which are subject to movement of fishes to and from waters of the state.

Waters of the United States: The navigable waters and territorial sea of the United States.

Watershed: An entire drainage basin including all living and non-living components.

Wildlife Code of Missouri: An annual publication which contains the rules and regulations of the Missouri Conservation Commission. It contains an “Approved Aquatic Species List” and a “Prohibited Species List.”

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APPENDIX A

MISSOURI PROHIBITED AQUATIC SPECIES LIST

Aquatic Species on the Missouri Prohibited Species List

The following species may not be purchased, sold, imported, exported, transported or possessed in Missouri without written permission of the Director of the Missouri Department of Conservation:

Fish *(including viable eggs)*

- Snakehead fish of the genera *Channa* or *Parachanna* (or the generic synonyms of *Bostrychoides*, *Ophicephalus*, *Ophiocephalus* and *Parophiocephalus*)
- Walking catfish of the family Clariidae

Invertebrates

- Zebra mussel (*Dreissena polymorpha*)
- Mitten crabs (genus *Eriocheir*)
- Rusty crayfish (*Orconectes rusticus*)
- Australian crayfish (genus *Cherax*)
- New Zealand mudsnail (*Potamopyrgus antipodarum*)

APPENDIX B

MISSOURI APPROVED AQUATIC SPECIES LIST

MISSOURI'S APPROVED AQUATIC SPECIES LIST	
Common Name	**Scientific Name**
Fishes	
Shovelnose sturgeon	*Scaphirhynchus platorynchus*
Paddlefish	*Polyodon spathula*
Spotted gar	*Lepisosteus oculatus*
Longnose gar	*Lepisosteus osseus*
Shortnose gar	*Lepisosteus platostomus*
Bowfin	*Amia calva*
American eel	*Anguilla rostrata*
Gizzard shad	*Dorosoma cepedianum*
Threadfin shad	*Dorosoma petenense*
Rainbow trout	*Oncorhynchus mykiss*
Golden trout	*Oncorhynchus aquabonita*
Cutthroat trout	*Oncorhynchus clarki*
Brown trout	*Salmo trutta*
Brook trout	*Salvelinus fontinalis*
Coho salmon	*Oncorhynchus kisutch*
Northern pike	*Esox lucius*
Muskellunge	*Esox masquinongy*
Goldfish	*Carassius auratus*
Grass carp	*Ctenopharyngodon idella*
Common carp	*Cyprinus carpio*
Bighead carp	*Hypophthalmichthys nobilis*
Golden shiner	*Notemigonus crysoleucas*
Bluntnose minnow	*Pimephales notatus*
Fathead minnow	*Pimephales promelas*
River carpsucker	*Carpiodes carpio*
Quillback	*Carpiodes cyprinus*
White sucker	*Catostomus commersoni*
Blue sucker	*Cycleptus elongates*
Bigmouth buffalo	*Ictiobus cyprinellus*
Black bullhead	*Ameiurus melas*
Yellow bullhead	*Ameiurus natalis*
Brown bullhead	*Ameiurus nebulosus*
Blue catfish	*Ictalurus furcatus*
Channel catfish	*Ictaluris punctatus*
Flathead catfish	*Pylodictus olivaris*
Mosquitofish	*Gambusia affinis*
White bass	*Morone chrysops*
Striped bass	*Morone saxatilis*
Green sunfish	*Lepomis cyanellus*
Pumpkinseed sunfish	*Lepomis gibbosus*
Warmouth sunfish	*Lepomis gulosus*
Orangespotted sunfish	*Lepomis humilis*
Bluegill	*Lepomis macrochirus*
Longear sunfish	*Lepomis megalotis*
Redear sunfish	*Lepomis microlophus*
Smallmouth bass	*Micropterus dolomieu*
Spotted bass	*Micropterus punctulatus*

Largemouth bass	*Micropterus salmoides*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Yellow perch	*Perca flavescens*
Sauger	*Sander Canadensis*
Walleye	*Sander vitreus*
Freshwater drum	*Aplodinotus grunniens*
Crustaceans	
Freshwater prawn	*Macrobrachium rosenbergii*
Northern crayfish	*Orconectes virilis*
White River crayfish	*Procambarus acutus*
Red swamp crayfish	*Procambarus clarkii*
Papershell crayfish	*Orconectes immunis*
Amphibians	
Tiger salamander larvae	*Ambystoma tigrinum*

APPENDIX C

ANS CURRENTLY FOUND IN MISSOURI

AND

ANS LIKELY TO ENTER MISSOURI

AQUATIC NUISANCE SPECIES (ANS) CURRENTLY FOUND IN MISSOURI		
Common Name	**Scientific Name**	**Comments**
	Plants	
Dotted duckweed	***Landoltia punctata***	**Currently found in the St. Louis area and in southeast and western Missouri.**
Eurasian watermilfoil	***Myriophyllum spicatum***	**Widespread. May be eliminated from existing habitats with great difficulty.**
Brittle naiad	***Naias minor***	**Common in ponds and lakes statewide.**
Purple loosestrife	***Lythrum salicaria***	**Common in north Missouri and the Missouri River valley.**
	Mussels	
Zebra mussel	***Dreissena polymorpha***	**Currently limited to Lake of the Ozarks, Taneycomo and the Missouri and Mississippi rivers**
	Mollusks	
Asian clam	***Corbicula fluminia***	**Common throughout Missouri. Low feasibility for eliminating from existing habitats.**
	Crustaceans	
Water flea	***Daphnia lumholtzi***	**Common in large lakes**
	Fish	
Common carp	***Cyprinus carpio***	**Widespread. May damage aquatic habitats when present in large numbers.**
Silver carp	***Hypophthalmichthys molitrix***	**Common in most large rivers. May compete with native species. Jumps and may injure boaters and water skiers.**
Grass carp	***Ctenopharyngodon Idella***	**Common throughout Missouri. Can be difficult to manage in ponds and lakes without eliminating aquatic vegetation.**
Bighead carp	***Hypophthalmichthys nobilis***	**Common in most large rivers.**
White perch	***Morone Americana***	**Found in Missouri and Mississippi rivers and tributaries in low numbers. Becomes overabundant in oxbows and could pose a threat to some resident fish communities if introduced. May invade large reservoirs.**

AQUATIC NUISANCE SPECIES (ANS) LIKELY TO ENTER MISSOURI		
Common Name	**Scientific Name**	**Comments**
Water hyacinth	***Eichhornia crassipes***	**Must develop cold water tolerance to survive in Missouri.**
Hydrilla	***Hydrilla verticillata***	**Found in Arkansas and Tennessee.**
New Zealand mudsnail	***Potamopyrgus antipodarum***	**Likely import via boots, waders, boats, etc.**
Quagga mussel	***Dreissena bugensis***	**Only one (1) individual found in Mississippi River in 2002.**
Rusty crayfish	***Orconectes rusticus***	**Introduction to the wild via bait buckets is very likely.**
Northern	***Channa argus***	**Possible introduction to the wild via aquarium**

snakehead		releases.
Black carp	*Mylopharyngodon piceus*	Predator on mussels and mollusks. May already exist in Missouri and Mississippi rivers and their large tributaries.
Ruffe	*Gymnocephalus cemuus*	Invasion via Great Lakes and Illinois River possible.
Round goby	*Neogobius melanostomus*	Invasion from Great Lakes via the Illinois River is possible.
Didymo	*Didymosphenia geminata*	Invasion from Arkansas waters is likely
Spiny water flea	*Bythotrephes ederstroemi*	Introduction by water or wild caught bait transfer from Great Lakes is possible.
Fishhook water flea	*Cercopagis pengoi*	Introduction by water or wild caught bait transfer from Great Lakes is possible.
Whirling Disease	*Myxobolus cerebralis*	Introduction by live salmonids transferred from the west or by contaminated gear is likely.
VHS	*Novirhabdovirus* sp.	Water, bait, and fish transfers are likely to introduce VHS from states the Great Lakes states.

APPENDIX D

SPECIES ACCOUNTS AND RISK ASSESSMENTS

FOR

MISSOURI'S AQUATIC NUISANCE SPECIES

Eurasian Watermilfoil

Scientific Name – Myriophyllum spicatum

Description – Eurasian watermilfoil, hereafter called milfoil, is a rooted, evergreen, aquatic plant which has short (several inches or cm), emergent, spikes of tiny pink flowers. It looks very similar to several native milfoil species. Milfoil stems branch profusely forming a dense canopy just under the water surface. The feathery leaves are tipped with a reddish tinge and are arranged around the sturdy stem in whorls of four (rarely five), and each one has 5-24 leaflets (segments). Milfoil also has horizontal roots, or stolons.

Reproduction – Milfoil appears capable of reproducing both sexually and asexually. Its flower heads produce ample seed, but seed germination has never been observed in either the wild or the laboratory (Smith and Barko 1990). Asexual reproduction is responsible for the spread of milfoil populations. Stolons enable milfoil to expand a few feet horizontally at a time. Milfoil plants fragment naturally after flowering, and at the end of the growing season. This results in the colonization of down-wind, downstream and down-valley habitats. It, however, is most commonly spread to new habitats by plant fragments attached to fishing and boating equipment.

Distribution – Milfoil is a native of Europe, Asia, and North Africa. Its similarity to native milfoil species makes it difficult to ascertain exactly when it first appeared in the US, but it was positively identified in the Washington D.C. area in 1942. From there, in theory, it spread to 46 states.

Habitat Associations – Milfoil lives and grows in a variety of habitat types including lakes, ponds, streams and rivers of all size. It thrives on all types of substrates and in waters ranging from oligotrophic to eutrophic. It forms dense canopies which shade-out and eliminate native aquatic plants and negatively affect fishing, boating, and swimming. Milfoil alters water chemistry, provides habitat for mosquito larvae (including those carrying viral diseases like the West Nile Virus), and leads to stunting of sport fish populations (Madsen et al. 1991; Crouch and Nelson 1991). Other problems resulting from milfoil mats include water-inflow inhibition because of clogging of “trash racks” and intake pipes.

Control Methods – Milfoil responds favorably to a variety of aquatic herbicides. Unfortunately, the same chemicals are effective on desirable native species. Attempts to control milfoil by mechanical methods most often lead to denser stands as a result of asexual fragmentation. Biological controls using a number of insects have been tried, and one using the weevil *Euhyrchiopsis lecontei* (Dietz) appears to hold promise (Creed and Sheldon 1994). Grass carp do not prefer to eat milfoil and if stocked to control an infestation will preferentially eat native aquatics until there is no alternative to milfoil.

Spread – Milfoil fragments are spread naturally and by man. New dense populations develop rapidly and are very costly to control. Washington, New York, Vermont, Wisconsin, and Minnesota have spent about $1 million each on milfoil control programs in severely infested lakes.

Conclusion – Eurasian watermilfoil is an ANS that poses a severe threat to Missouri’s aquatic resources.

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Eurasian Watermilfoil - Risk Assessment

Q. What is the possibility of milfoil reaching Missouri?
A. High – absolutely certain

Milfoil is already found in Missouri. Periodically over the last 30 years, milfoil has infested Lake of the Ozarks, negatively effected recreation and required large expenditures for herbicide treatment by private dock owners.

Q. What is the possibility of it surviving transit to Missouri?
A. High – absolutely certain

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – moderately certain

A 2-inch plant fragment is enough to start a new population of milfoil. This seems a likely probability.

Q. What is the probability that it will spread to new areas?
A. High – moderately certain

Downstream spread is probably inevitable given its ability to produce viable fragments for colonization. Man-caused spread to new watersheds is probably also inevitable unless active programs educating the public about the dangers of this ANS are implemented.

Q. What is the likely economic effect of milfoil?
A. High – moderately certain

Milfoil populations will cause major losses of recreation/tourism dollars. Some losses will be direct, such as the inability to boat and fish in infested waters, and part of the loss will come from fish populations which are out of balance because of the density of the vegetative canopy. Water for power generation and drinking may also be more difficult to find. Control programs are expensive and not very effective.

Q. What are the likely environmental effects?
A. High – moderately certain

Milfoil will alter water quality and fish populations. It will also have an undesirable effect on stands of native aquatic vegetation. Increases in disease-bearing mosquito populations will cause public concern and may alter public use patterns.

Q. What are the likely social and political effects?
A. High – moderately certain

Real property values will suffer greatly in areas with dense stands of milfoil and lead to a “demand” that someone do something. Diverting funds to milfoil control projects will have a negative effect on agency priorities.

Conclusion – Eurasian watermilfoil is an ANS which has the potential to cause severe problems for boaters, anglers, industry, homeowners, and native plants and fishes.

Purple Loosestrife

Scientific Name – *Lythrum salicaria*

Description – Purple loosestrife, hereafter called loosestrife, is a rooted plant found on moist or saturated soils. As many as 30 to 50 herbaceous stems rise from a common perennial rootstalk up to 2 feet (0.60m wide) to make a graceful wide-topped crown standing 6-8 feet (2.0-2.4m) tall. Leaves are paired and opposed and the stems are topped by masses of reddish-purple flowers each of which has 5-6 petals. Each plant annually produces approximately 2.7 million seeds which sink if they fall in water, but then float following germination. Loosestrife can form dense single-species blocks of vegetation over large wetland tracts. The attractive reddish-purple flowers turn bright red in the fall as the seasonal growth dehydrates. Dead stalks remain standing through the winter.

Reproduction – Sexual reproduction is of overriding importance in the establishment and spread of loosestrife. Seeds fall into water, sink, germinate, float and disperse. Wind dispersal of seeds is very limited, as is inadvertent dispersal in mud on vehicles, boots, or boats. Wildlife plays no role in seed dispersal. Seeds have been known to survive up to 3 years in dry, cold, climates. It is suspected that seeds survive much longer in Missouri.

Distribution – Loosestrife likely originally had a European origin. It is now found throughout the northern hemisphere up to 65º north latitude. In recent years, it has been reported from east Africa, Australia, and New Zealand. It has not yet been reported from South America or South Africa.

Habitat Associations – Loosestrife commonly can be found on moist or saturated soils in natural and man-made wetlands, along the banks of streams, canals, ditches, and rivers, and adjacent to ponds and lakes.

Spread – Initially, loosestrife reached North America as seeds or seedlings in the sand ballast of ships hauling goods and people to the new world. By the 1830's it was so well established along the eastern seaboard that it was considered a native species by naturalists. Its spread inland along natural and man-made waterways likely was the result of introduction by waterborne commerce into recently disturbed or stressed habitats. In recent years, highway construction projects may have opened new areas to loosestrife colonization.

Control Methods – Mechanical and miscellaneous controls (plowing, disking, pulling, cutting, fire, and water level manipulation have not been effective in reducing or eliminating stands of loosestrife. Chemical control with glyphosate (i.e. Rodeo) is possible, but time consuming and expensive. Follow-up sprayings are necessary for several years because of the dormancy of the root stock in any year. In other cases, new plants grow from seeds which have been in the soil for several years. New seedlings can also arrive from offsite and may necessitate annual sprayings for several years (Thompson, et al. 1999).

The most promising control technique appears to be the introduction of biological agents from Europe which are host specific to loosestrife. Fourteen insect species are currently being investigated. Some may be available for loosestrife control in the next decade. The cost to evaluate and produce these control agents is estimated at $500,000.00. It should be noted that biological control agents are most useful for infestations that are too large to eradicate with herbicides. Small infestations may not provide enough host plants to maintain the biological control agents and must be treated with herbicides or other methods.

Conclusion - Purple loosestrife is an ANS that is threatening to dominate the vegetative community of our wetlands, and stream and river banks.

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Purple Loosestrife - Risk Assessment

Q. What is the possibility of loosestrife reaching Missouri?
A. High – absolutely certain

Loosestrife is currently found at 45 sites in 23 counties.

Q. What is the possibility of it surviving transit to Missouri?
A. High – absolutely certain

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – moderately certain

Loosestrife is a ready invader of stressed or disturbed habitats. It has few, if any, native “enemies” and rapidly replaces cattail as the dominant wetland vegetation. It is attractive, and liked by private landowners. Chemical control is possible, but expensive and time consuming.

Q. What is the probability that it will spread to new areas?
A. High – moderately certain

Loosestrife is spread largely by floating seedlings. Downstream spread, especially to stressed or disturbed areas, along ditches, streams, and rivers is probably inevitable. Similarly, seeds dropped into the waters of ponds, lakes, and wetlands will float following germination and spread to other shoreline areas with changing wind directions.

Q. What is the likely economic effect of loosestrife?
A. Medium – moderately certain

Loosestrife is not a noted invader of cultivated fields or pastures. Its control using chemicals in wetland environments will be moderately expensive should it prove necessary.

Q. What are the likely environmental effects?
A. High – moderately certain

Invasion by loosestrife will diminish stands of native wetland plants that provide food and cover for waterfowl, shorebirds, muskrat, etc. Lower numbers of wildlife species mean fewer animals are available for wildlife viewers, hunters, and trappers.

Q. What are the likely social and political effects?
A. Medium – moderately certain

Loosestrife is an attractive plant, but one that has been declared a “noxious weed” in Missouri. Enforcing its control on private lands (at the landowner’s expense) is likely to be an unpopular process. The best hope for loosestrife control is the introduction of biological control agents on public lands that will then migrate to private lands.

Conclusion – Purple loosestrife is an ANS which has the potential to complicate management of many of our wetland habitats. Missouri should cooperate fully in the development of biological controls for this species.

Dotted Duckweed

Scientific Name- *Landoltia punctata*

Size and Lifespan- Dotted duckweed is an intensely green, tiny, floating, aquatic plant composed of fronds and 2 to 4 fine roots. The fronds are frost sensitive.

Reproduction - No information available.

Distribution- Dotted duckweed is variably reported as either an non native aquatic plant which originated in Southeast Asia and Australia or a native of Florida and the southeast US. In Missouri, it can be found in Jackson, Stoddard, and St. Louis counties. Those attributing its origin to sources outside the US usually indicate that it is believed to have been accidentally introduced, and later released, with other, more attractive aquarium plants. Like native duckweeds, dotted duckweed does well in nutrient-enriched environments.

Habitat Associations- Dotted duckweed is commonly found in quiet waters without substantial current such as ponds, lakes, ditches, canals, and marshes and other wetlands.

Possible Predators- Waterfowl are the primary consumers of dotted duckweed.

Spread- No information was encountered on how this species spreads to new environments. Presumably it may be spread by human actions (aquarium releases, physical transport, etc) and by waterfowl and other animals.

Conclusion- Dotted duckweed is an ANS which may replace native duckweeds and restrict the growth of submerged vegetation in some situations.

Dotted Duckweed - Risk Assessment

Q. What is the possibility of the dotted duckweed reaching Missouri?
A. High - absolutely certain

It has already been reported in 3 Missouri counties.

Q. What is the possibility of it surviving transit to Missouri?
A. High - absolutely certain

We already have it. Either it is a native species, or has already survived transit.

Q. Is it likely to establish viable populations where introduced?
A. High - absolutely certain

Dotted duckweed does well in quiet water environments.

Q. What is the probability that it will spread to new areas?
A. High - quite certain

It has done well so far and there’s no reason to think its abilities to expand its range will suddenly change for the worse.

Q. What is the likely economic effect of the dotted duckweed?
A. Low - quite certain

Infestations of dotted duckweed present the same economic effects as do those of native duckweeds.

Q. What are the likely environmental effects?
A. Low - quite certain

There is no evidence at present that dotted duckweed harms native plants or animals.

Q. What are the likely social and political effects?
A. Low - quite certain

Conclusion - Dotted duckweed is a low level threat to native plants and animals. Cooperation by anglers, boaters, and the aquaculture and aquarium industries can help limit the spread of this invasive species.

Brittle Naiad

Scientific Name- *Najas minor*

Size and Lifespan- This annual, submerged, thickly-branched aquatic plant grows to 4 feet (1.20 m) tall in clear waters. It seldom presents problems in deep water, but shallow waters such as the littoral zone of farm ponds can be severely clogged by dense growths.

Reproduction - Brittle naiad flowers from spring to early autumn. One seed is produced per flower. Stems and branches of the plants become brittle in late summer when they fragment and establish next year's seedbed in the bottom of the pond, lake, stream, river, or drainage ditch in which they are found. Seeds can be transported to new waters by currents, by passing through the guts of waterfowl, or by transport on fishing and boating equipment. The brittle naiad is capable of rapidly replacing native vegetation following introduction and clogging the water column of shallow water bodies (Vermont Agency of Natural Resources and the Nature Conservancy of Vermont 1998, U.S. Army Corps of Engineers 2002)

Distribution- Brittle naiad is native to Europe and Asia. It was first introduced to the U.S. by European shipping using the Hudson River in 1934 (McFarland *et al.* 1998). From there, it has spread rapidly throughout states east of the Mississippi River and is currently moving into Minnesota, Iowa, Missouri, and Arkansas.

Habitat Associations- Brittle naiad is also known as brushy naiad, slender naiad, spiny naiad, and marine naiad. It does best in clear shallow waters, but does not appear to be negatively affected by high levels of nutrients.

Control Methods- Brittle naiad seeds are readily eaten by waterfowl, especially mallards. Grass carp reportedly eat the naiad, but it is not a preferred food. Stocking rates over 10 per acre may be necessary to gain some control of brittle naiad growth, but may result in additional pressures on more desirable native plants. Regardless, new growths in subsequent years are probably inevitable since brittle naiad seeds are believed to pass undigested through the gut of grass carp. Brittle naiad can be

treated successfully with a wide variety of aquatic herbicides. Collateral damage to desirable native species is inevitable.

Spread- Brittle naiad is spread by dispersal of branch and stem fragments carrying seeds beginning in late summer. Dispersal mechanisms include transport on fishing and boating equipment, water currents, and in the gut of waterfowl.

Conclusion- Brittle naiad is an ANS that is rapidly infesting many ponds and lakes throughout Missouri and displacing native plants.

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Brittle Naiad - Risk Assessment

Q. What is the probability of the brittle naiad reaching Missouri?
A. High - absolutely certain

We already have the brittle naiad and it's rapidly expanding its range in Missouri.

Q. What is the probability of the brittle naiad surviving transit to Missouri?
A. High - absolutely certain

The best bet for stopping further introductions and spread of brittle naiad appears to be an active program educating anglers and boaters about the dangers of transporting plant fragments and seeds to new waters.

Q. Is it likely to establish and maintain a viable population where introduced?
A. Medium - quite certain

Brittle naiad won't do particularly well in turbid lakes, ponds, rivers, and streams. It also is vulnerable to a number of common aquatic herbicides which, if applied during the period of rapid growth in late spring and early summer, are very capable of eradicating stands of this invasive species. Drawbacks are effects to native species and application cost.

Q. What is the probability of it spreading to new areas?

A. High - quite certain

Even with an active boater and angler education program, waterfowl may inadvertently spread the brittle naiad.

Q. What are the likely economic effects of the brittle naiad?
A. Medium - quite certain

Keeping clear water lakes and ponds from being clogged by brittle naiad will be costly. Failure to control this invasive plant, however, will lead to large losses in recreational benefits associated with swimming, fishing, and boating.

Q. What are the likely environmental effects?
A. High - quite certain

Treating brittle naiad will likely damage populations of native aquatic plants. Failure to control the naiad will result in overabundance of fish cover and stunted forage fish populations.

Q. What are the likely social and political effects?
A. Medium - quite certain

Controlling brittle naiad will take funds and time from more productive fishery management activities and result in a dissatisfied clientele. Failure to treat will result in direct losses of recreational opportunities and upset anglers and boaters.

Conclusion - The brittle naiad is an ANS which currently poses a medium to high threat to Missouri's clear-water resources.

Daphnia lumholtzi

Scientific Name – ***Daphnia lumholtzi***

Size and Lifespan – *D. lumholtzi* populations increase throughout the summer and reach peak numbers in the warm waters of mid- to late-summer as the numbers of native species of *Daphnia* are dropping. Adults survive approximately one summer season and grow to 1.3 mm mean length (females) and 1.0 mm (males).

Reproduction – Like other species of *Daphnia*, *D. lunholtzi* survives cold water temperatures and periods of drying as "resting eggs", or ephippia. As conditions become favorable for *D. lumholtzi*, the ephippia hatch into females, grow, and begin to reproduce parthenogenetically. During this stage in their life cycle, the live-bearing females can produce up to 10 new females as many as 25 times a season. New females mature in 4 days and produce young females at 3 day intervals. With worsening conditions (lack of food, drying, or lower water temperatures), some eggs become males. The females which develop during this period produce eggs which must be fertilized. The small

embryos which develop from this sexual reproduction go into suspended animation as ephippia (all females) which are capable of surviving harsh conditions.

Distribution – *D. lumholtzi* is native to tropical and subtropical lakes in east Africa, east Australia, and the Indian subcontinent of Asia (Havel and Hebert 1993). It has established viable populations in a number of river systems and 56+ reservoirs in the southeast and midwest US (Havel *et al.* 1995). It was possibly introduced to Texas waters in 1983 with stockings of Nile perch.

Food Habits – Phytoplankton is the primary food of *D. lumholtzi*, but they also eat bacteria, fungi, and decaying organic material from a variety of sources. Their population numbers often mirror blooms of planktonic algae during mid- to late-summer and early fall. Most native *Daphnia* species are naturally dying back as populations of *D. lumholtzi* are peaking, so the population cycles do not appear to be related. Other zooplanktors, however, may face competition with this large “water flea”.

Habitat Preferences – *D. lumholtzi* prefers to occupy pond, lake, and reservoir habitats. Where present in riverine systems, it can most commonly be found in backwaters, seasonal floodplain ponds, and overflow waters.

Possible Predators – The large helmet and tail spines of *D. lumholtzi* are thought to render it relatively immune from predation by the fry of fishes (Kolar and Wahl 1998). Juvenile fishes, however, have no difficulty feeding on them and, in fact, white bass, crappie, and bluegill are selective for them (Lemke *et al.* 2003). Other species (freshwater drum and emerald shiner) demonstrated negative selectivity for *D. lumholtzi*.

Spread – The initial introduction of *D. lumholtzi* to the US quite possibly was the result of stockings of Nile perch in Texas. Once in a hatchery system, it could easily be spread to new lakes, ponds, and reservoirs with the stocking of fish. The hardiness of the ephippia stage likely led to rapid range expansions when transported in live wells, water in the bottoms of boats, and when attached to vegetation on boats and trailers. Other possible means of introduction (wind, and waterfowl) do not appear to be significant methods of range expansion.

Conclusion – *Daphnia lumholtzi* is an ANS currently found in many of our large reservoirs and river systems. Potential effects on native species of zooplankton, and on growth and survival of the fry of many native fishes are not yet known.

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Daphnia lumholtzi - Risk Assessment

Q. What is the possibility of *D. lumholtzi* reaching Missouri?
A. High – absolutely certain

D. lumholtzi has established populations in most of our large reservoirs and in many of our river systems.

Q. What is the possibility of their surviving transit to Missouri?
A. High – absolutely certain

The ephippia stage is very likely to survive when unintentionally stocked with fish from contaminated rearing facilities. It is also likely to successfully establish populations when it is introduced as a "stowaway" on, or in, fishing and boating equipment.

Q. Is it likely to establish viable populations where introduced?
A. High – moderately certain

The parthenogenetic life stage of *D. lumholtzi* is well-suited to producing large numbers of egg-bearing adults and instantaneously establishing a viable population. No information is currently available about the minimum numbers of ephippia necessary to establish a viable population.

Q. What is the probability that it will spread to new areas?
A. High – absolutely certain
D. lumholtzi was introduced to the US in 1983. Since that time, it has spread throughout the southeast and midwest. There appears to be a high probability of it successfully spreading to new waters.

Q. What is the likely economic effect of *D. lumholtz*i?
A. Low – moderately certain

At this time, the only economic effects relate to the possibility that changes in zooplankton populations will result in negative changes in sport fish survival and growth.

Q. What are the likely environmental effects?
A. Low – moderately certain

Native populations of zooplankton that commonly "bloom" in mid- to late-summer may be face competition from growing populations of *D. lumholtzi*. However, no definitive proof of this speculation exists at the present time.

Q. What are the likely social and political effects?
A. Low – moderately certain

Conclusion – *D. lumholtzi* is an ANS that has colonized most of our large reservoirs. The long-term effect of this invasive "water flea" on native zooplanktors and fish have yet to be determined.

Zebra Mussel

Scientific Name – *Dreissena polymorpha*

Size and Lifespan – Zebra mussels live for 4-5 years and can reach a maximum size of 1.9 inches (48 mm). Its name was inspired by the concentric, zebra-like rings on a paler background.

Reproduction – Female zebra mussels mature early in their second year of life when water temperatures reach 57-61º F (14-16º C). Like all other mussels, eggs and sperm are expelled into the water column where fertilization takes place. Each female releases approximately 40,000 eggs each reproductive cycle and as many as one million eggs each spring and summer. The larvae (veligers) emerge 3-5 days following fertilization and remain free-swimming for up to a month. The optimum temperature for larval development is 68-71º F (20-21.5º C). Juvenile mussels settle to the bottom and use their foot to crawl about in search of a suitable substrate. They attach by means of their byssal threads.

Distribution – The zebra mussel is native to the Balkans, Poland, Russia, and the Caspian Sea. The extensive development of canals and commercial barge traffic throughout northern Europe and Great Britain led to the development of viable populations of zebra mussels in the waters of a number of countries that are trading partners with the U.S. They were first found in Lake St. Clair in 1988. Subsequently, they invaded all of the Great Lakes and the Hudson and Mississippi (via the Illinois River) river systems. The zebra mussel is still actively extending its range throughout the Mississippi River basin and in other parts of the U.S. and Canada (Boydston and Benson 1992).

Food Habits – The zebra mussel is an efficient filter feeder specializing in all phytoplankton and zooplankton in the 15-40 micron size range. Each mussel filters approximately a quart of water each day. In the case of the Hudson River (which has very dense colonies of 700,000 mussels/m^2), the entire volume of river is filtered every 1-4 days. This filtering ability puts the zebra mussel in direct competition with native mussels, invertebrates, and larval and juvenile fish (Masteller and Schloesser 1991, Schloesser and Nalepa 1994). This competition has led to significant changes in the fish populations of the Great Lakes and the Hudson River (Griffiths 1993).

Habitat Preferences – Zebra mussels have a pronounced preference for attaching to hard substrates at 3-50 foot (1-15 m) depths in lakes and rivers. The quagga, a closely related species, originally populated softer substrates and deeper waters. Recent trends, however, are pointing to the quagga's ability to displace the zebra mussel from all substrates, including those that are shallow and hard.

Possible Predators – Native waterfowl and fish will likely eat zebra mussels, but probably will be incapable of controlling their numbers. Other ANS (eg., round goby and black carp) will likely prey on zebra mussels.

Spread – The zebra mussel is readily transported on commercial barges and recreational watercraft and trailers. Water in live-wells, motor cooling water, bilge water, and commercial vessel ballast water are all capable of transporting zebra mussels or their veligers. The natural movement of veligers leads to colonization of watersheds downstream from the point of initial introduction.

Conclusion – The zebra mussel (*Dreissena polymorpha*) is an ANS currently found in the Mississippi and Missouri rivers and has been recently identified in Lake of the Ozarks. It continues to be a threat to other inland waters, our large reservoirs, and our native fish and mussel populations. It is on the list of Prohibited Species in the *Wildlife Code of Missouri*.

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Zebra Mussel - Risk Assessment

Q. What is the possibility of the zebra mussel reaching Missouri?
A. High – absolutely certain

The zebra mussel is already well established in the Missouri and Mississippi rivers and has recently been identified in Lake of the Ozarks. The big challenge will be to solicit and obtain the cooperation of boaters, anglers, and waterfowl hunters to help keep the zebra mussel from invading our inland waters and large reservoirs.

Q. What is the possibility of their surviving transit to Missouri?
A. High – moderately certain

Zebra mussels can survive out of water for several days while attached to boating equipment. They also do well in live-wells, bilge water, and in engine cooling systems. We need to be proactive about soliciting cooperation from anglers, boaters, and hunters.

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – moderately certain

The zebra mussel is very adaptive and has shown that it is able to colonize and maintain populations in new areas.

Q. What is the probability that it will spread to new areas?
A. High – moderately certain

All it would take to introduce zebra mussels to our large reservoirs or inland waterways would be one boat with either live veligers or attached reproductively active adults.

Q. What is the likely economic effect of the zebra mussel?
A. High – absolutely certain

The zebra mussel is known to block water intakes, screens, and pipes. It also is likely to clog sewage treatment plants. When attached to docks, bridges, and breakwaters they can cause structural failures over time. Beaches are likely to be covered with small shells and shell fragments which are sharp and necessitate use of water-shoes. Boat motor cooling systems are also likely to be blocked.

Q. What are the likely environmental effects?
A. High – absolutely certain

Population structures of sport, commercial, and other native fishes are likely to be significantly damaged by the introduction of zebra mussels. The zebra's tendency to colonize the shells of live native mussels, and their ability to establish colonies of huge numbers of individuals, will likely affect phytoplankton and zooplankton populations and affect the growth of individuals in threatened populations.

Q. What are the likely social and political effects?
A. High – very certain

In many areas of colonization zebra mussel control has lead to increased costs for drinking water, sewage treatment, and industrial processes as well as a reduction in public use and tourism.

Conclusion – The zebra mussel is an ANS which is threatening our inland waterways and large reservoirs. Like its cousin the quagga mussel, it has the potential to cause severe environmental and economic effects.

Quagga Mussel

Scientific Name – *Dreissena bugensis*

Size and Lifespan – The quagga is a small (up to 4 cm) mussel which is closely related to the zebra mussel. It is pale, especially near the hinge, and has a number of dark, concentric rings extending outward to the shell's margin (Marsden *et al.* 1996).

Reproduction – The quagga, like all other true mussels, expel their eggs and sperm into the water column where fertilization takes place. Reproduction apparently takes place when water temperatures reach about 45º F (7º C). Individual females produce more than one million eggs in a spawning season.

Distribution – The quagga is native to rivers feeding the Black and Caspian seas and was first sighted in the US in Lake Erie in 1989 (Mills *et al.* 1996). It was probably introduced with ballast water discharged from international shipping. Since then it has rapidly expanded its range throughout the Great Lakes and appears to be rapidly displacing established populations of zebra mussels. In 2002, a specimen was collected between St. Louis and Alton, Illinois. Over its entire range, the quagga is more tolerant of cold water than is the zebra mussel.

Food Habits – Like the zebra mussel, the quagga is an extraordinary filterer capable of removing large quantities of phytoplankton and suspended particulates from the water. This decreases food available to zooplankton and larval fishes, and in many areas of the Great Lakes has essentially eliminated *Diporeia* sp., an amphipod at the base of the food chain for many commercial and sport fishes. The quagga feeds actively year-round. This differs from the feeding habits of the zebra mussel which is dormant during the winter.

Habitat Preferences – Initially, in the Great Lakes environment, the quagga could be found on softer substrates in 50 to 100 feet (15-30.5 m) of water (Bially and MacIsaac 2000). Over time they have expanded their habitats and now are found on both hard and soft substrates in all depths of water from 3 to 350 feet (1-107 m) (Mills *et al.* 1999). In rivers they appear to be equally at-home on hard and soft (silt or sand) substrates.

Possible Predators – Native fish like the freshwater drum and redear sunfish will feed to some extent on the quagga mussel.

Spread – The quagga, like the zebra mussel, is readily transported on barges, boats, trailers, fishing gear, and in live wells and boat motors. It colonizes downstream habitats rapidly once it is introduced. Like the zebra mussel, the quagga will have a major effect on the fisheries of inland lakes and reservoirs. Further, it will alter the food web of streams and rivers it colonizes and probably result in the extirpation of many of our native mussel species.

Conclusion – The quagga mussel (*Dreissena bugensis*) is an ANS that has been found in the Mississippi River. Similar to the zebra mussel, it is a threat to our inland lakes and reservoirs, and native mussel populations.

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Quagga Mussel - Risk Assessment

Q. What is the possibility of the quagga mussel reaching Missouri?
A. High – absolutely certain

The quagga has already been found (one individual) in the Mississippi River north of St. Louis and is likely to spread throughout the Mississippi and Missouri rivers. It may be possible to limit its spread to inland rivers, lakes, and reservoirs by proactively soliciting cooperation from boaters, anglers and other resource users.

Q. What is the possibility of their surviving transit to Missouri?
A. High – moderately certain

Larval quagga mussels are well suited to survive transit in live wells, and larvae and mussels attached to hulls, trailers, and fishing gear can survive several days out of water. Our best hope is to sensitize our constituents to the dangers associated with bringing their equipment from contaminated waters to uninfected areas of Missouri.

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – moderately certain

The quagga is capable of rapid genetic adaptation to new habitats. Once introduced it likely will develop and maintain viable populations.

Q. What is the probability that it will spread to new areas?
A. High – absolutely certain

The quagga mussel could spread throughout the Mississippi and Missouri rivers in a short time. Hopefully, we will be able to maintain awareness of the threats posed by quagga and zebra mussels and thereby limit their spread to inland rivers, lakes, and reservoirs.

Q. What is the likely economic effect of the quagga mussel?
A. High – moderately certain

The quagga is noted for clogging of water intakes, screens, and pipes. Significant costs are associated with correcting these intrusions. In other locations, quaggas are capable of covering docks, breakwaters, and beaches (with their razor-sharp shells) and damaging boat motors. Millions of dollars in annual costs for quagga mussel control will probably be passed along to consumers.

Q. What are the likely environmental effects?
A. High – very certain

Population structures of commercial and sport fish are likely to be significantly altered by the introduction of quagga mussels to Missouri waters. Their efficiency as phytoplankton filterers will directly affect native fishes and mussels. Reductions in populations of zooplankton will have severe negative effects on almost all native fish which feed on zooplankton at some stage of their life cycles.

Q. What are the likely social and political effects?
A. High – moderately certain

Conclusion – The quagga mussel is an ANS which has probably already spread throughout the Mississippi and Missouri rivers. Like its cousin the zebra mussel, it has the potential to cause severe environmental and economic effects.

Asian Clam

Scientific Name- *Corbicula fluminea*

Size and Lifespan- The Asian clam is small, rarely reaching 2 inches (5 cm) long. Individuals live from 1 to 4 years. In appearance, the Asian clam resembles the native fingernail clam, but it is readily identified by a series of concentric rings on its shell and its polished, light purple nacre.

Reproduction- Spawning season begins in early summer and lasts for approximately 6 months. Fertilization takes place in the inner gills and the veligers are expelled when they reach approximately 1mm. They settle to the bottom and begin their adult life, reaching sexual maturity at 6-10 mm.

Distribution- The Asian clam is a freshwater species whose home range includes southern and eastern Asia and Africa. It probably was introduced to the western U.S. as a food item in the 1930s. Currently it can be found throughout much of the country, but especially adjacent to costal environments, and throughout the Ohio, Tennessee, and Mississippi drainages. In some areas it has reached densities up to 2,000 individuals/m^2. In Missouri, the Asian clam is common in the Mississippi, Black, St. Francis, Meramec, Gasconade, and lower Osage drainages.

Food Habits- Like native mussels, the primary food source of Asian clams is aquatic phytoplankton. Since they can occur in such tremendous numbers, they are direct competitors for available food. The Asian clam is more tolerant of poor water quality than are native species (Sinclair and Isom 1961). On occasion, however, the Asian clam can experience mass die-offs. This results in spectacular reductions in their densities, but also negatively effects native mussel species that are sensitive to decomposition products such as ammonia.

Habitat Preferences- Asian clams are found in sandy and muddy bottomed streams, rivers, ponds, and lakes. It, as mentioned above, is tolerant of waters affected by discharges of excessive nutrients. It also can be found in great numbers in brackish estuarine environments like San Francisco Bay.

Possible Predators- Fish such as freshwater drum and redear sunfish will likely consume Asian clams. Resident and migratory waterfowl will also feed on them. Attempts to interest people in trying Asiatic clam chowder and other dishes have largely proven unsuccessful.

Spread- Asian clams are spread by the same mechanisms as are other non native mussels-water in bilges, motors, live wells, and attached to fishing and boating gear.

Conclusion- The Asian clam is an ANS which may have severe effects on our native mussel populations.

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Asian Clam - Risk Assessment

Q. What is the probability of the Asian clam reaching Missouri?
A. High - absolutely certain

The Asian clam has been present for many years in the Black, Gasconade, Meramec, Mississippi, Osage, St. Francis and White river drainages. At many locations it is present in great numbers and directly competes with native species.

Q. What is the possibility of the Asian clam surviving transit to Missouri?
A. High - absolutely certain

The Asian clam is already here.

Q. Is it likely to establish and maintain viable populations where introduced?
A. High - absolutely certain

The Asian clam is a “generalist” tolerant of poor water quality. It has consistently thrived wherever it has been introduced. There is no reason to expect this pattern to change.

Q. What is the probability that it will spread to new areas?
A. High - quite certain

Asian clams may be accidentally transported to all of our major reservoirs. From there, they will likely spread downstream and eventually be found throughout the Missouri River drainage.

Q. What is the likely economic effect of the Asian clam?

A. Medium - quite certain

The Asian clam has the potential to clog power plants, industrial facilities, water intake and treatment facilities, and boat motors. However, thus far, negative effects on such facilities have not been observed.

Q. What are the likely environmental effects?
A. Medium - quite certain

Asian clams directly compete for food and living space with native mussel populations. In high water quality environments, native mussels will persist in the presence of Asian clams. In poorer water quality conditions, the competition from Asian clams may result in the depletion of native mussels.

Q. What are the social and political effects?
A. Low - quite certain

Conclusion - The Asian clam is an ANS which currently poses a medium threat to native mussels. Cooperation by boaters and anglers and boaters will be essential I limiting the expansion of this “generalist” to new waters.

Common Carp

Scientific Name- *Cyprinus carpio*

Size and Lifespan- The carp is a heavy-bodied minnow with barbels on both sides of the upper jaw. Dorsal color varies from a yellowish-brassy green to golden brown, or even silver. Ventrally, the carp is usually a yellowish-white color. Carp have been known to live up to 47 years, and 20 years is not at all uncommon. Individuals weighing 8 to 10 pounds (3.6- 4.5 kg) and measuring up to 25 inches (0.60 m) are common. The world record carp measured 75 pounds 11 ounces (34 kg).

Reproduction - Carp mature in 2 to 5 years. Spawning commences in the spring when water temperatures reach 62° F (16.6º C), usually sometime in May. Fecundity varies with the size of the female and ranges from 36,000 to over 2 million eggs for a large female. The female discharges its many small, adhesive, eggs over beds of aquatic plants or brush where they are fertilized by nearby males. Fry hatch in 3 to 6 days when they reach approximately 10 mm. Following hatching, the fry feed on plankton.

Distribution- The carp is native to Asia where it has been prized as a food fish for centuries. It was imported to Europe for its food and sport value. It was intentionally stocked at many locations in the U.S. beginning in 1831 and first released in Missouri in 1879. From its original stockings, it has spread nation-wide and currently poses problems in many locations. They are one of the most widely distributed species of fish Missouri (Pflieger 1997).

Food Habits- Carp are omnivorous; feeding on plants and bottom dwelling animals with equal facility. They compete with native fish for food, uproot plants from the bottom and create turbidity

problems as a result of their feeding activities. Carp are direct competitors with diving ducks such as canvasbacks for a number of aquatic plants. They also eat the young of many native mussels and are efficient predators of fish eggs.

Habitat Preferences- Carp may be found in a variety of habitats ranging from lakes, ponds, streams, and rivers which are clear and oligotrophic to those which are shallow, muddy, and eutrophic. Carp have become serious nuisances in shallow, turbid lakes and ponds.

Possible Predators- Young carp are readily taken by all of our native and introduced game fish. This period of vulnerability, however, is relatively short because of their rapid growth rates. There is little interest in the commercial harvest of carp from our major rivers, because of the "muddy" taste attributed to their flesh. Carp often become overabundant especially in shallow, turbid waters where sight-feeding predators are at a disadvantage.

Spread- Effective means of managing carp numbers must be developed in areas where they have become a nuisance.

Conclusion- The common carp is a long-term resident of Missouri. In many locations, however, it has become an ANS which merits serious attention by fisheries managers.

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Common Carp - Risk Assessment

Q. What is the probability of the carp reaching Missouri?
A. High - Absolutely certain

Carp is one of most widely distributed species. It will be nearly impossible to keep it out of any new waters that are created for recreational fishing and boating, or other uses.

Q. What is the possibility of the carp surviving transit to Missouri?
A. High - absolutely certain

See above.

Q. Is it likely to establish a viable population wherever it is introduced?
A. High - absolutely certain

See above.

Q. What is the probability it will spread to new areas?
A. High - absolutely certain

Short of killing all fish life in the entire watershed of new lakes and ponds, and carefully inspecting live bait subsequently used for fishing, there's not much that can be done to limit colonization of new areas.

Q. What are the likely economic effects of carp?
A. Low - quite certain

The growth and harvest of native fish may be reduced by the presence of carp. This will lead to a reduction in recreational benefits and expenditures where carp become problem ANS. Also, their food habits may disrupt limnological cycles and deter waterfowl from using affected waters. Locally, economies may suffer.

Q. What are the likely environmental effects?
A. Medium - quite certain

Carp do best in shallow, warm-water, environments which are typical of streams, rivers, ponds, and lakes in north and west-central Missouri. They have been common in those areas for many years and additional negative effects are unlikely.

Q. What are the likely social and political effects?
A. Low - absolutely certain

Conclusion - The common carp is an ANS that is already widespread in Missouri. Because of its reproductive capabilities and feeding habits, it has the potential to be a serious problem in selected waters.

Grass Carp

Scientific Name ——*Ctenopharyngodon idella*

Size and Lifespan – Grass carp have an average adult maximum size of approximately 40 pounds (18 kg) in weight and 4-5 feet (1.2-1.5 m) in length. An occasional fish, however, may reach 5 feet (1.5 m) and 70 pounds (32 kg). They live for approximately 10-15 years.

Reproduction – The grass carp is an obligate big river spawner. Females 3 to 4 years old and 15 pounds (7 kg) typically spawn 100,000+ floating eggs when water temperatures reach approximately 65ºF (18º C). Larger females produce proportionally more eggs. The eggs float downstream, hatch, and the fry collect in off-channel, quiet, water conditions (Robison and Buchanan 1988).

Distribution – Grass carp, like all other Asian carps, are native to China and the Amur Basin of eastern Russia. They survive in a variety of habitats between 22º and 51º N latitude, a range that includes the US, southern Canada, and Europe. The grass carp has been stocked in more than 50 countries for aquatic plant control. It was first introduced to the US in 1963 by Auburn University in cooperation with the USFWS. It has been artificially propagated at many commercial fish farms, sold

widely for weed control in ponds, escaped, and established breeding populations in the wild. In the US, only Vermont and Montana are currently without grass carp populations.

Food Habits – Grass carp have specialized pharyngeal teeth that allow them to grind and eat aquatic plants. Digestion of this plant matter is quite inefficient; approximately 50% passes through the fish without being digested. This often leads to increases in turbidity and blooms of planktonic algae. Fry eat protozoans, rotifers, copepods, and cladocerans. As they age, benthic algae, phytoplankton, and organic detritus are added to their diet. Eventually, their diet consists largely of higher aquatic plants. Most of their feeding takes place near the water surface where they eat the tender new growth first. Eventually, they will eat the plant downwards to its roots. Grass carp are dormant and eat very little during the winter months. When water temperatures reach 68º F (20º C) in the spring, the grass carp begins actively feeding. Preferred plants include pondweed (*Naias* sp.), water primrose, *Elodea* sp., *Hydrilla* sp., and Eurasian watermilfoil (Lewis 2004).

Habitat Preferences – Despite being an obligate big river spawner, the grass carp survives in streams of all size, ponds, and large lakes or reservoirs which have good stands of aquatic vegetation.

Possible Predators – The grass carp is a particularly tasty fish. Unfortunately, it is also extremely difficult to catch by hook and line methods. Attempts to remove grass carp from ponds when goals for vegetation removal have been met, have largely been unsuccessful.

Conclusion – Grass carp are an ANS with the potential to negatively affect native fish populations, largely because of their effects on breeding sites and resting and escape cover. Although the grass carp has been a resident of Missouri since the 1970s, we still do not understand its long-term effects on our native fauna.

Literature Cited

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Grass Carp - Risk Assessment

Q. What is the possibility of the grass carp reaching Missouri?
A. High – absolutely certain

We already have grass carp in many ponds, lakes, reservoirs, streams, and rivers. They have established viable populations in our big rivers.

Q. What is the probability of their surviving transit to Missouri?
A. High – absolutely certain

Grass carp can be found statewide.

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – absolutely certain

It established breeding populations in the 1970s.

Q. What is the probability that it will spread to new areas?
A. Low – moderately certain

The grass carp is already established in many aquatic systems in Missouri.

Q. What are the likely economic effects of grass carp?
A. Medium – moderately certain

Grass carp reduce stands of certain aquatic plants that provide feeding and escape cover for native fishes. Lower growth rates and lower sport fish population densities very likely will result in fewer dollars spent fishing.

Q. What are the likely environmental effects?
A. High – moderately certain

The long term effects of grass carp on native fish and invertebrate communities are poorly understood at present. We suspect that changes in population structures, standing crops, and growth rates are inevitable, but little evidence has been collected.

Q. What are the likely social and political effects?
A. Medium – very certain

Grass carp are sold as an alternative (to chemical control) method of aquatic vegetation control by the aquaculture industry. In fact, triploid grass carp are recommended and used for aquatic plant control in research ponds, public lakes, and private recreational ponds.

Conclusion – Grass carp are an ANS whose effects on native fish, invertebrate, and aquatic plant populations are not yet known.

Bighead Carp

Scientific Name— *Hypopthalmichtys nobilis*

Size and Lifespan – Adult bighead carp can grow to 110 lbs (50 kg) and 60 inches (1.5 m) long. Their most prominent distinguishing characteristic is the placement of their small eyes – low and forward on the head underneath the midline and approximately even with the junction of their upper

and lower jaws. Little is known about their growth rates in the wild, but their large size suggests that they live at least 10-12 years.

Reproduction – Bighead carp become ready to spawn when water temperatures reach approximately 65º F (18º C) in late spring or early summer. Mature fish of both sexes migrate variable distances upstream where they spawn. Young (20+ inches (0.50 m) long and 3-4 years old) spawning females may release as few as 300,000 floating eggs. With increasing size, more eggs are spawned. In fact, larger females spawn between 660,000 and 1.2 million eggs depending on their size. Depending on water temperature, the eggs may hatch in as little as one day as they drift downstream (Verigin *et al.* 1990).

Distribution – Bighead carp are natives of lowland rivers in eastern China. They were brought to the US in the 1970s to see if they were capable of improving water quality in commercial catfish rearing facilities. Eventually, they escaped and established breeding populations in the Missouri and Mississippi rivers and their tributaries. Breeding populations currently exist throughout the entire Missouri and Mississippi rivers, in California and Florida, and are threatening to enter the Great Lakes via the Chicago Sanitary and Ship Canal (Robison and Buchanan 1988). A number of Great Lakes states and the Corps of Engineers have contributed to the construction and operation of an "electric curtain" in the canal to keep the bighead and other Asian carps out of Lake Michigan.

Food Habits – Bighead carp of all sizes are filter feeders. The gill rakers they use to collect food are long, comb-like, and close together. As they swim they collect and eat large numbers of zooplankton, phytoplankton, and even detritus. The bighead is an open water schooling fish that locates and eats its prey very efficiently. Potentially, it competes for food with native fishes such as the paddlefish, bigmouth buffalo, gizzard shad, the fry of most other Missouri fishes, and also with our native mussel fauna. The direct results of this competition are likely to be reduced growth rates and decreasing numbers of native fish and mussels (Burke *et al.* 1986). Bighead carp have been caught on limb and trotlines, and will occasionally take live bait, bass plugs, and spinners.

Habitat Preferences – As mentioned, bighead carp are open water schooling fish. They migrate to suitable shallow water areas to spawn their floating eggs. They are common in tributaries to the Missouri and Mississippi. The mouths of such tributaries are excellent locations for finding bighead carp. The onset of cold weather and dropping water temperature (<55ºF or <13º C) finds them moving to deep waters where they spend the winter. They continue to feed actively until water temperatures reach 37ºF (2.7ºC). Substrate does not appear to play a significant role in the selection of bighead carp habitat.

Possible Predators – The bighead carp, like all other Asian carps, is a tasty food fish that anglers can soon learn to clean and cook (Michaelson 1999). Commercial fisheries for bigheads are developing in areas where they're present in good numbers and where profitable markets exist. In fact, many commercial and sport anglers have learned to collect bigheads by motoring through areas where they commonly are located. While young bigheads are probably eaten to some extent by larger native predators such as the blue catfish, there do not appear to be any native fishes which selectively prey on them.

Spread – The only barriers to the spread of bighead carp are watershed boundaries, dams, and electrical curtains. If they ever find their way into our system of reservoirs, they will have major effects on very important recreational fisheries.

Conclusion – The bighead carp is an ANS that has already reached extremely high densities and therefore may be having major effects on the native fish faunas of the Missouri and Mississippi rivers and their tributaries.

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Bighead Carp - Risk Assessment

Q. What is the possibility of the bighead carp reaching Missouri?
A. High – absolutely certain

The bighead carp has already established viable populations in the Missouri and Mississippi rivers and the lower ends of tributary streams and rivers.

Q. What is the probability of the bighead carp surviving transit to Missouri?
A. High – absolutely certain

They're already here in large numbers.

Q. Is it likely to establish and maintain a viable population where introduced?
A. High - absolutely certain

The bighead carp is a "big river" spawner. It already exists and prospers in all of our big river habitats.

Q. What is the probability that it will spread from areas which are originally colonized?
A. Medium – quite uncertain

Concerns exist that the bighead carp may adapt and successfully spawn in some of our longer tributary rivers like the Chariton, Current, Gasconade, Grand, Meramec, Niangua, Osage, Salt and Platte.

Q. What is the likely economic effect of bighead carp?
A. High – moderately certain

Bighead carp are so common in some areas that they interfere with commercial fishermen attempting to take other species. Jumping fish damage boats and injure passengers and negatively affect fishing, boating, and hunting on the big rivers.

Q. What are the likely environmental effects?
A. High – very certain

Bighead carp directly compete for food with all native species at some stage of their life cycle. Some fish, like the paddlefish, bigmouth buffalo, and gizzard shad, are in direct competition with them throughout their entire lives. Growth rates and survival of native fishes may suffer in the face of this competition.

Q. What are the likely social and political effects?
A. Medium - moderately certain

Conclusion – The bighead carp is an ANS which is already present in the Missouri and Mississippi rivers and the lower ends of certain tributaries.

Silver Carp

Scientific Name – *Hypopthalmicthys molitrix*

Size and Lifespan – Adult silver carp have been known to reach 40+ inches (1 m) and 110 pounds (50 kg). Their small eyes are located beneath the fish's midline, and are set low and forward on their head. They probably live 10-12 years in the wild.

Reproduction: Silver carp move upstream with spring spates and spawn in groups of 15-25 fish when water temperatures reach 64-71ºF (18-22º C) (Verigin *et al.* 1978). Spawning females, depending on their size, release 0.5-1.9 million floating eggs which are fertilized by nearby males (Kamilov and Komrakova 1999). The fertilized eggs drift downstream until they hatch. The fry continue to drift downstream and eventually move out of the main channel and into adjacent slack water areas. On the Missouri and Mississippi rivers this typical habitat can be found downstream of wing dikes, in chutes, and in the mouths of tributaries.

Distribution – Silver carp are native to lowland rivers in China and to the Amur River in far eastern Russia. They were introduced to the US in 1973 by an Arkansas fish farmer who was interested in using them to control algal blooms in catfish ponds, and possibly as a food fish (Nico 2004). The silver carp escaped and now has established breeding populations throughout the Missouri and Mississippi rivers and their tributaries. Other rivers in the Gulf of Mexico drainage have established breeding populations which originated from fish stocked in sewage lagoons, reservoirs, and fish farms to control algal blooms. The silver carp has also invaded the Illinois River and ascended the Chicago Sanitary and Ship Canal almost to its junction with Lake Michigan.

Food Habits – Young silver carp feed selectively on zooplankton. Adults, however, prefer phytoplankton – if it's available. If phytoplankton is scarce, adults also will feed on zooplankton. The silver carp has a characteristic feeding behavior. It swims rapidly just below the surface rapidly gulping water, closing its mouth and pumping it out its gill flaps. The plankton is collected on the gill rakers which are fused into sponge-like porous plates and subsequently ground-up by the pharyngeal teeth and a cartilaginous plate (Robison and Buchanan 1988). Silver carp may compete with native fish such as the paddlefish, bigmouth buffalo, gizzard shad, and the fry of almost all native fish. This competition will result in changes in the makeup of the plankton populations, and reduced growth rates and numbers for both native fish and mussels. Silver carp have occasionally been taken on trotlines and by anglers snagging in slack water behind wing dikes.

Habitat Preferences – Adult silver carp are an open water fish most commonly found off the main river channel behind wing dikes, in chutes, and in the mouths of tributaries. These areas were previously used by native fishes as spawning and resting habitats. Young of the year silver carp will concentrate in backwater or floodplain waters where they feed on the abundant plankton populations. Re-flooding of these waters releases them back into the nearby river. A recent fish kill in a backwater of the Mississippi River revealed that more than 90% of the fish killed were silver, bighead, and grass carp. Confused and disturbed fish jump wildly, and a number actually land in the boat. Unfortunately, many boaters and anglers have been injured as a result of the jumping fish. The silver carp does not seek out the deepest water in which to over-winter. Instead, they remain active and continue to feed at water temperatures as low as 37ºF (2.7º C).

Possible Predators – The silver carp is a tasty food fish that anglers can learn to clean and cook (Chapman 2004). If profitable markets existed for silver carp, they could be supplied in good numbers by commercial fishermen. Boaters and anglers must be aware of the dangers posed by silver carp which jump wildly when motorboats pass nearby. The combination of a boat moving at 20 mph (32 kph) and a 20 pound (9 kg) fish jumping from the water has led to a number of serious injuries. Young silver carp are likely eaten by a number of native predators, but no native fish appears to selectively prey on them.

Spread – The spread of silver carp is currently limited by watershed boundaries and dams. If they are ever introduced to our large reservoirs, they will have major effects on a number of very important recreational fisheries. Their jumping behavior could make recreational boating, angling, and water skiing in such environments quite hazardous and ultimately effect tourism.

Conclusion – The silver carp is an ANS that has already reached extremely high densities and therefore may be having major effects on the native fish faunas of the Missouri and Mississippi rivers and their tributaries.

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Silver Carp - Risk Assessment

Q. What is the possibility of the silver carp reaching Missouri?
A. High – absolutely certain

The silver carp has established viable populations in the Missouri and Mississippi rivers and their tributaries.

Q. What is the possibility of their surviving transit to Missouri?
A. High – absolutely certain

They're already here in large numbers.

Q. Is it likely to establish and maintain a viable population where introduced?
A. High – absolutely certain

Like the bighead, the silver carp is a "big river" spawner. It exists and prospers in all of our big river habitats.

Q. What is the probability that it will spread to new areas?
A. Medium – quite certain

The silver carp can survive in big reservoirs and rivers smaller than the Missouri and Mississippi. If they are able to successfully spawn in these smaller rivers and rivers tributary to the reservoirs, few barriers will exist to keep them from successfully colonizing additional waters

Q. What is the likely economic effect of silver carp?
A. High – moderately certain

Silver carp are so numerous in some areas that they interfere with commercial fishermen attempting to take other species. They are active jumpers and have caused damage to boats and injured passengers. The silver carp has had negative effects on fishing, boating, and hunting on our big rivers.

Q. What are their likely environmental effects?

A. High – very certain

Silver carp eat zooplankton and phytoplankton at different stages in their life cycle. In doing so, they compete for food directly with native fishes, mussels, and snails. Silver carp will likely have long-term negative effects on the survival and growth of native species.

Q. What are the likely social and political effects?
A. Low – moderately certain

Conclusion – The silver carp is an ANS which is already present in the Missouri and Mississippi rivers and the lower ends of streams and rivers tributary to them.

White Perch

Scientific Name – *Morone americana*

Size and Lifespan – A few white perch may live 10 years and reach 19 inches (48 cm) in length, but in Missouri they most commonly attain maximums of 5-7 inches (13-18 cm) and weigh less than 1/3 pound (0.2 kg). Once introduced, local fish communities often become overpopulated with large numbers of small white perch.

Reproduction – White perch mature and spawn when they reach 5 inches (13 cm). Each female spawns up to 300,000 adhesive eggs in the spring when water temperatures reach 50-60ºF (10-15.5 C). Their preferred spawning habitat is tributary streams off large rivers like the Missouri, or streams feeding lakes. At 60ºF (15.5 C), the eggs hatch in as little as 30 hours.

Distribution – White perch are native to freshwater, estuarine, and marine habitats from Lake Ontario and the Gulf of St. Lawrence to Charleston, South Carolina. Following completion of the Erie and Welland canals, it spread throughout the Great Lakes (Johnson and Evans 1990). Fish stocked in Nebraska in 1964 (Hergenrader and Bliss 1971) escaped and spread to Kansas and Missouri. Currently, the white perch is common in some northwest Missouri oxbows of the Missouri River (Pflieger 1997). Illegal introduction to other impoundments could create problems for sportfish.

Food Habits – Fish eggs are an important component of the diet of white perch. Their preferred prey is eggs of walleye and white bass and numerous studies have documented significant declines in native fish populations, presumably because of a lack of recruitment (Schaeffer and Margraf 1987). During other times of the year, and at other stages in their life cycle, their diets are similar to those of white bass – with whom they often hybridize. Competition for food with large numbers of stunted white perch may result in lower growth rates for native fishes.

Habitat Preferences – The white perch occupies both river and lake habitats. In one Nebraska lake, within three years it completely replaced the previously dominant black bullhead. Species composition changed from 79% black bullhead to 70% white perch in that short period of time (Hergenrader and Bliss 1971).

Possible Predators – Although many native fishes of appropriate size will eat white perch, none are capable of controlling its population growth. Its small size makes it undesirable from a sport angler's perspective, although they do taste similar to white bass.

Conclusion – The white perch is an ANS that has caused localized problems in Northwest Missouri lakes.

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White Perch - Risk Assessment

Q. What is the possibility of the white perch reaching Missouri?
A. High – absolutely certain

The white perch has established viable populations in the Missouri River and its overflow waters in northwest Missouri. It is currently spreading downstream.

Q. What is the possibility of their surviving transit to Missouri?
A. High – absolutely certain

They are already here in large numbers in some oxbow lakes.

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – absolutely certain

Q. What is the probability that it will spread to new areas?
A. High – very certain

There are no barriers to their spread throughout the watersheds of the Missouri and Mississippi rivers and they are expected to do so. Our hope is that they are not introduced to the watersheds of our large reservoirs.

Q. What is the likely economic effect of white perch?
A. Medium – moderately certain

White perch could contribute to declines in populations of native fishes in impoundments. This could mean a loss of income to local communities if traditional recreational fisheries decline.

Q. What are the likely environmental effects?
A. Medium – moderately certain

Population structures of native fishes could be altered in the presence of white perch.

Q. What are the likely social and political effects?
A. Medium – moderately certain

Conclusion – The white perch is considered an ANS in the oxbow lakes of the Missouri River in Northwest Missouri. If introduced to our large reservoirs, it has the potential to cause environmental and economic problems.

Water Hyacinth

Scientific Name – *Eichhornia crassipes*

Description – Water hyacinth is a free-floating plant which grows up to 3 feet (1 m) tall. It has thick, waxy, rounded, glossy leaves which rise well above water level on bulbous and spongy leaf stalks. Flower stalks are thick, up to 20 inches (0.50 m) tall, and topped by 8-15 showy purplish blue or lavender flowers, each of which has 6 petals. Its roots are feathery and extend downward from the floating plant.

Reproduction Habits – Water hyacinth reproduces both asexually and sexually. In the former mode, short runner stems, or stolons, radiate from the base of the plant and form "daughter" plants. The "daughters" remain attached until they are broken-off by wind or other physical damage. Vegetative reproduction is very rapid and enables the raft of plants to double in size every 6 to 12 days. In the sexual mode, each flower blooms for several days before beginning to wither. When all the flowers on a stalk have bloomed, the stalk gradually bends until the flowers are submerged. Seeds are released from the seed capsule after about 18 days and remain viable for up to 20 years.

Distribution – The water hyacinth is native to tropical regions of South America. It has been exported to other tropical and sub-tropical areas around the world by people interested in its profuse floral presentation. It was introduced to the US in 1884 at the Cotton Centennial Exposition held in Louisiana. Currently, it can be found in California and all the southeastern states. The range of the water hyacinth appears to be restricted to areas where the air temperatures do not get below 20º F (-6.6º C). Few, if any, such areas are present in Missouri.

Habitat Associations– Water hyacinth grows and thrives in a wide variety of wetland habitats over its entire range including lakes, ponds, rivers, streams, ditches and other waterways, and natural and man-made marshes. In some countries water hyacinth has been used in waste treatment facilities with significant success. In all habitats, however, it has the ability to form dense mats of vegetation

which eliminate native plants and alter water chemistry. Its dense mats negatively affect fishing, boating, swimming, and water flow (Fact Sheet 2003).

Control Methods – Mechanical, biological, and chemical control methods have been developed for water hyacinth, but all are expensive. Mechanical controls (removal) can not keep pace with rapid plant growth in large water systems. Water hyacinth is susceptible to a number of commonly available aquatic herbicides. Unfortunately, the high cost of chemical control of water hyacinth makes it a high visibility effort which may also negatively affect remaining species of desirable native aquatic plants. Biological controls have been developed around a number of insects (2 weevils and a moth) (Grodowitz 1998). Such approaches, however, are long range and, as yet, slow acting. Grass carp only infrequently eat water hyacinth.

Spread – Water hyacinth is readily available for sale as a decorative aquatic plant. Escapes from captive situations are likely responsible for new range expansions.

Conclusion – The water hyacinth is a potential ANS, but one that is not currently capable of surviving Missouri winters. It will be a threat to our aquatic resources if it develops cold weather tolerance.

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Water Hyacinth - Risk Assessment

Q. What is the possibility of water hyacinth reaching Missouri?
A. Low – moderately certain
Water hyacinth is currently incapable of surviving Missouri winters.

Q. What is the possibility of their surviving transit to Missouri?
A. High – moderately certain

Commercial suppliers of water hyacinth do not have any problems shipping the plants and their seeds to Missouri, and elsewhere.

Q. Is it likely to establish and maintain viable populations where introduced?
A. Low – moderately certain

Missouri's winters are too cold for the species to become established and reproductively viable.

Q. What is the probability that it will spread to new areas?
A. Low – moderately certain

See above.

Q. What is the likely economic effect of the water hyacinth?
A. Low – moderately certain

If the species should develop a cold weather tolerance, the costs to control it will be high.

Q. What are the likely environmental effects?
A. Low – moderately certain

If we ever do get the water hyacinth, we will encounter high costs for its control, negative effects on native plant and fish communities, and loss of boating, swimming, and angling opportunities. Industries dependant upon water supply and domestic surface water supplies will also be affected.

Q. What are the likely social and political effects?
A. Low – moderately certain

As long as we don't have the water hyacinth, effects will be minimal. If a cold weather tolerant strain develops, the effects are likely to be significant.

Conclusion – Water hyacinth is a potential ANS which could be expensive to control if a cold tolerant strain develops.

Hydrilla

Scientific Name – *Hydrilla verticillata*

Size and Lifespan – Hydrilla is a rooted aquatic plant that grows in ponds, lakes, rivers, canals, and wetlands at depths ranging from 18 inches (0.45 m) to 30+ feet (9+ m). In clear water, hydrilla plants often reach lengths of 25-30 feet (7.6 m-9.0 m). It forms dense mats at the water surface that inhibit the growth of other, more desirable, plants (Rizzo *et al.* 1996; van Rijk 1985). It is able to do well in both oligotrophic and eutrophic waters, including those which receive large amounts of treated and untreated sewage.

Reproduction – Two varieties of hydrilla can be found in the US. The southern dioecious strain (all female plants) was imported to Florida from India in the early 1950s by an aquatic plant dealer in the aquarium trade. The northern monoecious strain which was imported from Korea in the 1980s (probably as a contaminent in shipments of water lilly) has both male and female flowers on the same plant (Madeira *et al.* 1997). Both strains can sprout new plants from root fragments, stem fragments with two whorls of leaves, tubers, and tunions. Tubers are formed underground at the ends of roots and may remain dormant for several years. Tunions are over-wintering buds produced along the leafy stems. Both tunions and tubers can withstand ice cover, drying, herbicides, ingestion and regurgitation by waterfowl, and consumption and elimination by grass carp.

Distribution – Hydrilla is native to the Indian subcontinent, Africa, and Australia. It has been spread world-wide and currently can be found south of 55º N latitude throughout the northern hemisphere. In

the US, hydrilla can be found along the eastern sea coast from Maine to Florida, throughout states bordering the Gulf of Mexico, and on the west coast in Arizona, California, and Washington. No specimens of hydrilla have been collected in Missouri, but it has been recorded in both Tennessee and Arkansas.

Habitat Associations – Hydrilla is found in lakes, ponds, rivers, streams, and canals where it is introduced.

Possible Predators/Control Methods –Hydrilla spreads through fragmentation, so attempts to control it mechanically are unlikely to be successful. Biological control using stockings of grass carp, another ANS, provides generally good results since hydrilla is a preferred food (Colle and Shireman 1980). Chemical controls, however, are not specific to hydrilla. Of the chemicals that do work, Sonar is expensive and appears to be slow acting and non-specific. Never the less, it is the herbicide of choice for treating broad areas. Aquathol is a fast-acting contact herbicide. It is used for immediate control of hydrilla in limited areas like swimming beaches and marinas.

Spread – Hydrilla spreads to new habitats in uninfected watersheds as a result of accidental or intentional introduction of whole or partial plant fragments. All of North America below 55º N latitude is susceptible to invasion by hydrilla.

Conclusion – *Hydrilla verticillata* is an ANS which has been found in the neighboring states of Arkansas and Tennessee. It is a serious and expensive threat to native aquatic plants, fish populations, and water-based recreation.

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Hydrilla - Risk Assessment

Q. What is the possibility of hydrilla reaching Missouri?
A. High – moderately certain

Hydrilla is accidentally spread by man as plants or plant fragments attached to boats and trailers.

Q. What is the possibility of their surviving transit to Missouri?
A. High – moderately certain

Hydrilla stem fragments, tubers, and tunions are well able to survive transit to new habitats.

Q. Is it likely to establish and maintain viable populations where introduced?
A. Medium – moderately certain

Hydrilla is an adaptable plant that is well able to survive and thrive in a wide variety of habitats, but has not shown this ability in Missouri waters.

Q. What is the probability that it will spread to new areas?
A. Medium – moderately certain

Since hydrilla is able to attain high densities through asexual propagation of new plants from plant fragments, tubers, and tunions, it is quite likely that man will unintentionally spread it to new habitats. Due to the lack of hydrilla populations, immediate spread to new areas seems unlikely.

Q. What is the likely economic effect of hydrilla?
A. Medium – moderately certain

Hydrilla forms dense mats and interferes with swimming, boating, fishing, and water skiing. Florida spent nearly $50 million on hydrilla control during the 1980s, but experienced an approximate 40% expansion during that same period. South Carolina spends about $2.5 million annually on hydrilla control. In water supply lakes, hydrilla could negatively affect water storage and delivery which would lead to increased consumer costs. While hydrilla has created severe economic effects in southern states, it has not yet appeared in Missouri.

Q. What are the likely environmental effects?
A. Medium – moderately certain

Hydrilla forms dense mats on the water surface which shade-out native vegetation. These mats raise the pH, decrease the dissolved oxygen available for aquatic life and increase temperatures due to solar absorption. Dense hydrilla stands tend to support few desirable-sized sport fish (Colle and Shireman 1980). Instead, large numbers of small, slow growing, stunted individuals are common. Large fish kills are possible (Rizzo *et al.* 1996). While hydrilla has created severe environmental effects in southern states, it has not yet appeared in Missouri.

Q. What are the likely social and political effects?
A. Low – moderately certain

Stands of hydrilla which interfere with traditional recreational use of aquatic habitats will generate demands for “management” by the public, regardless of the cost. Increased costs associated with diminished water supplies for domestic or industrial usage are additional problems.

Conclusion – Hydrilla is an ANS which appears to have limited ability to grow in Missouri's waters. However, its effects have been severe in other locations.

New Zealand Mudsnail

Scientific Name – *Potamopyrgus antipodarum*

Size and Lifespan – The mudsnail grows to shell lengths of approximately 6mm in US waters. It begins to reproduce at about 3mm. The mudsnail lives for 1+ years in captivity (Richards 2002).

Reproduction – This non native snail reproduces parthenogenically (ie., asexually) in US waters. It reproduces year-round, but is most active from March to October. Little reproductive activity has been observed in the winter months. The mudsnail has the potential (single female with no mortality, 6 generations per year, and 50 offspring per snail) for one snail to initiate the production of over 30 million new snails per year. In western lakes and rivers, it has reached densities of 500,000 to 800,000 individuals/m², or >90% of the total invertebrate biomass (Bowler 1991).

Distribution – West and east slopes of the Rocky Mountains, the headwaters of the Missouri River, and at least one location in Kansas.

Food Habits – The mudsnail is an obligate scraper. Almost all of its food is diatoms and periphyton. Some sources have estimated that they may consume up to 75% of primary production in certain streams (Kloeppel *et al.* 2003). The mudsnail out-competes native invertebrates for food. This leads to decreases in diversity and abundance of native benthic macroinvertebrates. The mudsnail is potentially a major threat to trout streams, Ozark waterways, other streams and rivers, and reservoirs throughout Missouri.

Habitat Preferences – The mudsnail is commonly found on substrates of silt, gravel, sand, cobble, and vegetation.

Possible Predators – Freshwater drum and redear sunfish may consume mudsnails.

Spread – Although its range expansion in any particular watershed slows down when it reaches a reservoir, it likely will spread downstream quite quickly by high flows. A single mudsnail transported to new waters while attached to fishing equipment, boots, boats, and trailers is enough to establish a new population.

Conclusion – The New Zealand mudsnail is an ANS which may arrive in Missouri in the next few years. It is on the list of Prohibited Species in the *Wildlife Code of Missouri*.

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New Zealand Mudsnail - Risk Assessment

Q. What is the possibility of the mudsnail reaching Missouri?
A. High – very certain

One mudsnail reaching Missouri by being transported on fishing and boating equipment is adequate to establish a reproducing population. Also, they are currently located in the watershed of the upper Missouri River. Downstream colonization is likely through natural range expansion.

Q. What is the probability of the New Zealand mudsnail surviving in transit to Missouri?
A. High – very certain

The mudsnail is very small and can be easily transported in vegetation and mud on fishing gear. Exposure to high temperatures or prolonged freezing can kill individuals in transit.

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – very certain

The mudsnail is a generalist. It can be found on all types of substrates and eats diatoms and other periphyton. Most fish are incapable of digesting the mudsnail. The fact that it reproduces asexually improves its chances of establishing new, viable, populations.

Q. What is the likelihood that it will spread from areas which are originally colonized?
A. High – very certain

The mudsnail is relatively quick moving, readily transported downstream in high flows, and easily transported on fishing and other gear. Additionally, it may be transported in the gut of aquatic birds.

Q. What is the likely economic effect if mudsnails become established?
A. Medium – moderately certain

Mudsnails have a major effect on food webs and may affect tourism focused on specific fisheries.

Q. What are the likely environmental effects?
A. High – very certain

Mudsnails may, when present in large numbers, consume up to 75% of a water body's primary production. Since they are largely immune to predation, the mudsnail's effects will be profound. The

inevitable result of their introduction is a reduction in the numbers and pounds of fish produced by any stream, river, pond, or lake.

Q. What are the likely social and political effects?
A. Low – moderately certain

Missouri's wild trout management areas may be negatively effected as are the trout streams on the western slopes of the Rocky Mountains. Other specialty fisheries may also be affected.

Conclusion – The New Zealand mudsnail is an ANS which has a high likelihood of reaching Missouri in the next few years.

Rusty Crayfish

Scientific Name – *Orconectes rusticus*

Size and Lifespan – Adult rusty crayfish have an average body size of about 2 1/2-3 inches (6.4-7.6 cm). Males can reach 4 inches (10 cm) total length (measured without their claws). They molt approximately 8-10 times following hatching during the spring and early summer. The first 3-4 molts take place while the young are attached to the swimmerets of the female. Adult females molt once per year and the males twice, hence their larger size. They can reach 4 years old, but significant numbers perish from natural mortality during each molt.

Reproduction – Mature rusty crayfish mate in late summer, early fall, or early spring. The female stores the spermatophores (sperm packets) externally. As her eggs are released (April or May) they are fertilized and attached to her swimmerets with glair. The 100-500 eggs hatch in 3 to 6 weeks, depending on water temperature. Rusty crayfish reach sexual maturity when they reach a size of 1 3/8 inches (4.4 cm), usually in their second year of life (Hobbs and Jass 1988). Adult males molt in late summer when their gonopods take on the Form I (sexually active) shape. The gonopods take on the sexually inactive Form II shape with the spring molt the following year. Adult females molt only once each year following incubation of eggs and young.

Distribution – The rusty crayfish is native to streams and lakes in the Ohio River basin in Ohio, Kentucky, and Indiana. It is also native to southern Michigan. Currently, it can be found in 18 states and Canada (Gunderson 2004).

Food Habits – The rusty crayfish is an opportunistic omnivore. It feeds on a variety of aquatic plants, benthic macroinvertebrates, detritus and associated periphyton, fish eggs, small fish, and other crayfish which have recently molted. In the laboratory the rusty crayfish has been successfully cultured in, and fed exclusively upon, layered brown paper towels in the bottoms of aquaria. In the wild, the rusty crayfish has been credited with causing substantial changes in the diversity and abundance of aquatic macrophytes and benthic macroinvertebrates. The survival of the eggs of certain warm water fish is also suspected to be affected by rusty crayfish predation (Lodge and Lorman 1987, Olsen *et al.* 1991).

The rusty crayfish displaces native crayfish by directly competing for preferred hiding places. Fish predation on native species increases since their common response in the presence of predators is flight. The rusty crayfish, on the other hand, assumes an aggressive “claws-up” posture which reduces its susceptibility in the face of potential predators (Garvey *et al.* 1994).

Habitat Preferences – The rusty crayfish inhabits streams, rivers, and lakes which offer rocks, logs, and other types of cover and which have bottoms of cobble, gravel, sand, clay, or silt. They do not burrow, and require habitats which have water of sufficient quality and quantity year-round. Their young are readily found in stands of aquatic macrophytes.

Possible Predators – The rusty crayfish is less subject to predation by fish than are the native crayfishes it replaces. Bass, walleye, sunfishes, and, to a limited extent, catfishes are possible predators in Missouri waters. Its large size, and excellent taste, makes the rusty a desirable food item for humans.

Spread – It only takes a single female rusty crayfish with attached spermatophores to establish a viable population in new waters. Everyone needs to be careful not to transport bait from one watershed to another. If the rusty is introduced to Missouri, it will likely spread and displace and eliminate a substantial number of our 33 native crayfish species. The range of the rusty crayfish has expanded substantially since the 1960’s. Its spread to new waters is thought to have occurred as a result of “bait bucket” introductions by anglers. Once present, the rusty quickly builds its population and spreads throughout a particular drainage and into adjacent ponds and lakes. The reverse (lake to stream and river) also takes place. Once in place, it may again be spread by anglers collecting bait for use in additional locations.

Conclusion – The rusty crayfish is an ANS that may arrive in Missouri in the next several years. It is on the list of Prohibited Species in the *Wildlife Code of Missouri*.

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Rusty Crayfish - Risk Assessment

Q. What is the possibility of the rusty crayfish reaching Missouri?
A. High – very certain

The rusty is a generalist species that has become common throughout the upper Midwest and Canada. There is no question it will do well here. Angler introductions are likely. However, an outreach program with bait shop owners and managers in Missouri is currently underway. It is too soon to estimate the program's success, but, if it works we may significantly postpone the arrival of the rusty crayfish.

Q. What is the probability of the rusty crayfish surviving in transit to Missouri?
A. High – very certain

The rusty, like all other crayfish, is able to survive almost indefinitely out of water if kept damp.

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – very certain

Habitat and climate appear to be well-suited for rusty crayfish survival in Missouri. Food also appears to be plentiful. All that would be needed to establish and maintain a new population would be a fertilized female, or a breeding pair.

Q. What is the likelihood that it will spread from areas which are originally colonized?
A. High – very certain

All of Missouri is open to invasion by rusty crayfish. There is no reason to suspect that the species will suddenly cease exploiting new habitats.

Q. What is the likely economic effect if rusty crayfish become established?
A. Medium – moderately certain

We will need to become more aggressive in monitoring bait shops to be sure that rustys are not being transported to new waters. This will require a fiscal commitment. No selective toxicants for rusty crayfish exist. Elimination of rusty crayfish populations in ponds is possible using toxic chemicals. Stream populations of rusty crayfish, however, can only be eliminated if you are willing to kill off all crayfish (and possibly all invertebrates and fish). If the goal is simply to reduce the density of rusty crayfish, they will need to be trapped from early spring to late fall.

Q. What are the likely environmental effects?
A. High – very certain

The introduction of rusty crayfish will have substantial effects on the density and diversity of stands of aquatic macrophytes, populations of benthic macroinvertebrates, and the survival and abundance of many of Missouri's 33 native crayfish species. Sport fishing also will be negatively effected.

Q. What are the likely political effects?
A. Low – very certain

Bait shop owners in Missouri have voluntarily eliminated the sale of rusty crayfish. The only negative effect is likely to be on non-resident anglers who now cannot bring rusty crayfish from other states for use as bait.

Conclusion – The rusty crayfish is a potential ANS which has a high likelihood of invading MO in the next few years.

Northern Snakehead

Scientific Name – *Channa argus*

Size and Lifespan – Specimens up to 5 feet (1.5 m) and 40 pounds (18 kg) are known. Few, if any, age and growth studies have been done, but the snakehead probably exhibits patterns typical of other temperate teleostean fishes.

Reproduction – The snakehead reaches sexual maturity in 3 years at a length of 12-14 inches (30-35 cm). The snakehead builds nests in aquatic vegetation by clearing circular openings approximately 3 feet (1 m) in diameter, in water 24-31 inches (60-80 cm deep) and "weaving" loose strands of vegetation into the nest's walls. Normal fecundity ranges from 1,300- 51,000 eggs per spawn, depending upon the size of the female which can spawn up to 5 times per year. Both adults guard the non-adhesive pelagic eggs which hatch in 2 days at water temperatures of 73º -77º F (23-25º C). Parental care continues until the young reach a size of approximately 0.70 inches (18 mm) (Fuller 2004).

Distribution – The northern snakehead can be found in China, Korea, Japan, Mongolia, Siberia, Russia, Czechoslovakia, and, most recently, the US. It has been collected in California, Maine, Massachusetts, Maryland, Rhode Island, Virginia, Hawaii, Florida, Wisconsin, Texas, and North Carolina, but has established reproducing populations only in Maryland (Courtenay and Williams 2004).

Food Habits – The northern snakehead is a voracious feeder during its entire life cycle. Post-larval snakeheads feed on zooplankton. Juveniles eat small crustaceans and larval fish, and adults consume other fish, frogs, crayfish, and aquatic insects. Some reports have juvenile snakeheads feeding in schools. In Maryland, a pond containing snakeheads was treated with a toxicant that killed all the fish. The total number of snakeheads recovered was greater than the number of native fish. However, the weight of native fish exceeded the weight of the snakeheads. In this one case, it is obvious that the snakeheads fed primarily on small native fish and dramatically affected their survival.

Habitat Preferences – The snakehead is an obligate air breathing fish. It can be found in stagnant or shallow ponds with aquatic vegetation and mud or silt bottoms. It can be found in a variety of other habitats, but most appear to have aquatic vegetation close to shore.

Possible Predators – The literature contains anecdotal mention of snakeheads introduced to ponds containing other top predators such as largemouth bass. There, snakeheads persist at low population densities without having effects similar to those noted in Food Habits (above). The extent of their effects may prove to be based upon the amount of aquatic vegetation in the water body.

Spread – The snakehead is able to survive poor water quality because of its air breathing ability. It is also able to "walk" or "wiggle" from one body of water to another across dry land on its pectoral fins. Its possible release from aquariums, aquaculture facilities, and its tolerance of cold water and ice make it a possible threat to spread throughout Missouri and the upper Midwest. The northern snakehead is a popular item in Asian fish markets. Its ability to breath air enables it to live for considerable periods of time if kept damp. It also is a popular aquarium fish. Its distribution in the US appears to be largely the result of releases from aquariums. Its high price in the Asian food markets, however, points to the possibility of accidental releases from aquaculture facilities in other states.

Conclusion – The northern snakehead is an ANS that may arrive in Missouri in the next few years. It is on the list of Prohibited Species in the *Wildlife Code of Missouri*.

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Northern Snakehead - Risk Assessment

Q. What is the possibility of the northern snakehead reaching Missouri?
A. High – moderately certain

The northern snakehead was raised commercially in Arkansas until it was made illegal in 2002. Established snakehead populations were discovered in Arkansas' waters in 2008. At one time, it was also sold in a live fish market in St. Louis, and still is a popular aquarium fish. There is no question that it can survive Missouri winter conditions. Ponds and river systems with abundant beds of aquatic vegetation appear to be particularly threatened.

Q. What is the probability of the northern snakehead surviving in transit to Missouri?
A. High – very certain

Being an obligate air breathing fish, the snakehead is capable of surviving transport to fish markets. If it escaped from culture ponds in Arkansas prior to 2002, it may already be making its way to Missouri.

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – very certain

Habitat and climate appear favorable for snakehead survival in Missouri. In addition, preferred foods are locally abundant for fueling their survival, growth, and reproduction – all that is needed is one breeding pair of snakeheads.

Q. What is the likelihood that it will spread from areas which are originally colonized?
A. High – reasonably certain

Most of Missouri's aquatic habitats are susceptible to colonization by northern snakeheads. Northern Missouri waters, and other waters that are relatively turbid, may not be preferred habitats, but, many examples can be shown where northern snakeheads in China, Korea, and Russia are present in similar habitats.

Q. What is the likely economic effect if northern snakeheads become established?
A. Medium – moderately certain

Rotenone, a non-selective fish toxicant, appears to be capable of killing snakeheads in waters without dense stands of aquatic vegetation even though it is an air breather. In many cases, however, habitats with populations of snakeheads will need to have stands of vegetation treated with an appropriate herbicide prior to rotenone treatment. Regardless, the cost of removing northern snakeheads from ponds and lakes appears to be significant. No way of preserving native fish while treating snakeheads currently exists.

Q. What are the likely environmental effects?
A. High – very certain

The introduction of northern snakeheads will result in effects to populations of native fishes as a result of predation, competition for food, and changes in food webs. Snakeheads also appear to be more protective of their young than are native fishes. All of these factors point toward the possible domination of water bodies by snakeheads rather than native fishes. Sport and commercial fisheries are likely to suffer.

Q. What are the social and political effects?
A. Low – moderately certain

Snakeheads are currently a small component of the aquarium fish trade. They have been placed on the prohibited species list in the *Wildlife Code of Missouri* (Appendix A).

Conclusion – The northern snakehead is a potential ANS, but the likelihood of invading Missouri has been reduced by placing it on the prohibited species list. Previous trade in snakeheads was limited so social and political effects of this prohibition are likely minimal.

Black Carp

Scientific Name – *Mylopharyngodon piceus*

Size and Lifespan – The typical adult black carp reaches 3 feet (1M) in length and weighs approximately 33 pounds (15 kg). The maximum recorded size is 5 feet (1.5 M) long and 150 pounds (68 kg). Individual fish have been observed to live up to 15 years in captivity.

Reproduction – Black carp become sexually mature at 15-25 pounds (7 -11 kg), usually in 6-10 years. Depending on body size, mature females produce from 129,000 to 1.2 million eggs annually. They spawn in large, fast-flowing rivers similar to the Missouri and Mississippi when water temperatures reach 65ºF (18ºC) and when water levels are rising. Their floating eggs drift downstream with the current to floodplain lakes, smaller streams, and quiet backwaters.

Distribution – Black carp are native to all of China, eastern Russia, and northern Vietnam where they inhabit lakes and fast flowing rivers between 22ºN and 51ºN latitude – an area comparable to most of the US, including the Great Lakes. They were imported to the US as “contaminants” with shipments of grass carp in the 1970s. In the 1980s, black carp were imported as a food fish and as a bio-control for snails which served as intermediate hosts for yellow and white grubs in commercial catfish production facilities in Arkansas and Missouri. More recently, Mississippi permitted aquaculture facilities a one year exemption to their requirement that all black carp be certified as triploid. During this time, it appears that a small number of reproductively viable (diploid) black carp were present in shipments of predominantly (97-98%) triploid fish. Since 2001, all black carp entering Mississippi have been certified as triploids. Black carp have been collected in the wild from a number of locations (Mississippi River, Red River, Illinois River), but no evidence of breeding populations in the wild has, as yet, been collected.

Food Habits – Black carp fry feed on zooplankton and the fry of native fishes. As they mature, their diet switches to snails and mussels. They are well equipped for this role since they possess strong pharyngeal teeth and gill rakers which are fused into strong plates. Throughout their life, however, they also prey on crayfish, fresh water shrimp, and aquatic insects. This diet brings them into direct competition with native fishes and waterfowl that eat large numbers of fingernail clams, and species of wildlife like raccoon, otter, and muskrat. The black carp’s most serious effects are likely those they have on native species of snails and mussels - their primary food source. Adult black carp eat approximately 4 pounds of mussels per day. If reproducing populations are established in Missouri waters, some of our already threatened native mussel populations could come under additional stress.

Habitat Preferences - Black carp inhabit off-channel, relatively quiet, waters which produce large numbers of snails and mussels. They probably move to deeper water to over-winter, and upstream to spawn, as do the other Asian carps.

Possible Predators – Like the other Asian carp, the black carp is a tasty food fish. Its apparent low densities in the wild at the present time make it unlikely that a viable commercial fishery will develop. The black carp does not jump into boats like the silver and bighead carp.

Conclusion – The black carp is an ANS that has the potential to further imperil many native snail and mussel populations throughout Missouri, not just in the Missouri and Mississippi rivers.

Black Carp - Risk Assessment

Q. What is the possibility of the black carp reaching Missouri?
A. High – moderately certain

To date, no evidence exists that the black carp has established viable populations in our big rivers. Anecdotal evidence from commercial fishermen on the upper Mississippi River, however, indicates that the black carp may be present there in low numbers.

Q. What is the possibility of their surviving transit to Missouri?
A. High – absolutely certain

Mississippi is currently permitting reproductively viable black carp to be used in aquaculture facilities. If they should escape, there are no barriers to keep them from swimming upstream to Missouri waters.

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – absolutely certain

Conditions in Missouri's big rivers and their tributaries appear suitable for black carp.

Q. What is the probability that they will spread to new areas?
A. Medium – moderately certain

The black carp are likely to survive in Missouri's big reservoirs and rivers smaller than the Missouri and Mississippi. If they are able to successfully spawn in our smaller rivers, our native snail and mussel populations in these habitats will probably suffer severe declines.

Q. What is the likely economic effect of black carp?
A. Low – very certain

Commercial harvest of native mussels for fresh water pearls and buttons from our big rivers is no longer a viable industry. Few, if any, other economic effects are likely to be caused by black carp.

Q. What are the likely environmental effects?
A. High – absolutely certain

Our already threatened native mussels and snails may face additional pressures if the black carp establishes viable populations in Missouri.

Q. What are the likely social and political effects?
A. Low – moderately certain

Conclusion – The black carp is an ANS which, in the worst possible scenario, could reach and establish breeding populations in Missouri within the next few years.

Eurasian Ruffe

Scientific Name- *Gymnocephalus cernuus*

Size and Lifespan- The ruffe is a small, but aggressive relative of the yellow perch. In the wild, it rarely exceeds 4 to 6 inches (10-15 cm) in total length. It has spiny dorsal and anal fins, and a head without scales. Females generally live 11 years and males 7 years (Ogle 2000).

Reproduction- The ruffe grows rapidly and may reach sexual maturity in its first year of life. They spawn over a variety of substrates at water temperatures ranging from 40.8-68º F (4.9 to 20° C). Females spawn up to six times per year averaging about 200,000 eggs on the initial spawn and 6,000 eggs on subsequent spawns. Eggs hatch in 5 to 12 days, depending on water temperatures. Larvae and fingerlings tolerate temperatures ranging from 44.6-86º F (7 to 30° C).

Distribution- The Eurasian ruffe is native to lakes and rivers in Europe and western and central Asia. It was introduced to Lake Superior in ballast water discharges from transoceanic shipping in 1986 (Ryan 1996). Since then, it has also been introduced (or spread) to the waters of Lakes Huron and Michigan. Wherever it has been introduced it has rapidly displaced native species. It is very tolerant of poor water quality and is a threat to enter the Mississippi River drainage via the Chicago Sanitary and Ship Canal. Once the ruffe reaches the Illinois and Mississippi rivers, it is likely to spread throughout all Missouri waters directly connected to the Mississippi.

Food Habits- Depending on their size and life stage, ruffe eat a variety of prey including rotifers, copepods, dragonfly and caddisfly larvae, cladocera, a wide assortment of other benthic macroinvertebrates, fish eggs and larvae (Selgeby 1998), and young fish.

Habitat Preferences- Ruffe can be found in a wide variety of habitats including small streams, large rivers, ponds, lakes, swamps, and estuaries. Their extremely high reproductive potential, generalist feeding habits, and tolerance of conditions has led to their rapid displacement of native fish populations following introduction (Great Lakes Fishery Commission 1992).

Possible Predators- The spiny nature of the ruffe ensures that it is largely immune to predation by native species. Studies which involved supplemental stockings of walleye and northern pike in a river and embayment off Lake Superior were unable to attribute any ruffe population control to these predators. It is unlikely that any Missouri predator will show any greater tendency to pursue and take ruffe in any significant numbers.

Spread- The ruffe is currently restricted to the drainage of the Great Lakes. If it should gain access to the Mississippi River drainage, we will be invaded by an ANS which has no desirable attributes.

Conclusion- The Eurasian ruffe is an ANS which may have a severe effect on our native fish communities in the future.

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Eurasian Ruffe - Risk Assessment

Q. What is the probability of the ruffe reaching Missouri?
A. Low - moderately certain

The Corps of Engineers and Great Lakes states have agreed to jointly construct an electric curtain in the Chicago Sanitary and Ship Canal to restrict the spread of a number of ANS into and out of the Great Lakes. This barrier should greatly limit the spread of ruffe into the Mississippi River drainage. The potential of a contaminant in wild caught bait transferred to Missouri could be a pathway for ruffe introduction.

Q. What is the possibility of the ruffe surviving transit to Missouri?
A. Low - quite certain

As long as power outages are avoided, the ruffe should be restricted to the Great Lake drainages.

Q. Is it likely to establish and maintain a viable population if it is introduced?
A. High - absolutely certain

The ruffe is a "generalist" with a high reproductive rate. There is no question that they will thrive under Missouri conditions.

Q. What is the probability that it will spread to new areas?
A. High - quite certain

Ruffe will spread rapidly to connecting waters. However, they are unlikely to spread to Missouri waters above dams. They have no value as baitfish, so the only way they might spread to these upstream areas is as contaminants in fish stockings and wild caught bait.

Q. What is the likely economic effect of ruffe?
A. High - very certain

Ruffe could have negative effects on native fish populations. Dollars generated by anglers and tourists in pursuit of native fish will be diverted to other areas by the ruffe contamination.

Q. What are the likely environmental effects?
A. High - very certain

Ruffe may have negative effects on survival and growth of native fish.

Q. What are the likely social and political effects?
A. Medium - moderately certain

Conclusion - The Eurasian ruffe is an ANS which currently poses a medium threat to native fishes.

Round Goby

Scientific Name – *Neogobius melanostomus*

Size and Lifespan – Adult round gobies range from 4-10 inches (10-25.4 cm) long. Females become sexually mature in 1-2 years and males at 3-4 years. Throughout their lives, round gobies are very aggressive and rapidly displace native benthic fishes such as sculpins and darters. They live for 6-7 years.

Reproduction – Female gobies mate from April through September producing 300-5,000 eggs per spawn. Males guard the nests and are aggressive about driving sculpins and darters from preferred nesting areas. These multiple spawns enable invading gobies to quickly establish viable populations.

Distribution – The native range of the round goby is the Black and Caspian seas and the rivers feeding them. The round goby was introduced to the Great Lakes in discharges of ballast water from international shipping. From its initial discovery in the St. Clair River in 1990, it has spread throughout the Great Lakes. It has also been collected from the Chicago Sanitary and Ship Canal which connects with the Mississippi River via the Illinois River (Jude *et al.* 1992). The round goby has spread throughout the Great Lakes in the 14 years since its introduction. The time necessary for it to spread throughout the Illinois River system and reach the Mississippi River is not known. If it becomes established in Missouri, it could have a major effect on native Ozark stream fishes.

Food Habits – Young gobies feed extensively on benthic macroinvertebrates and are direct competitors with darters and sculpins (French and Jude 2001). They also consume eggs and fry of darters, sculpins, and other fish. With increasing size, their diet shifts to one composed primarily of zebra and quagga mussels (Weimer and Sowinski 1999). In certain rocky or gravelly substrates, the round goby has been seen to reach densities of up to 20 fish/m^2. Small zebra and quagga mussels are preferred forage items, and as many as 78 have been found in samples of goby stomachs. In experimental enclosures in western Lake Erie, gobies reduced zebra mussel populations by 66%.

Habitat Preferences – The round goby inhabits inshore areas in lakes and appears to prefer rocky and gravelly substrates. In rivers it presumably prefers riffle habitats. In winter, however, it moves to

deeper water areas. Its aggressive behavior has led to rapid decreases in darter and sculpin populations, partially from direct predation and partially from their displacement to less suitable habitats (Marsden and Jude 1995, Dubs and Corkum 1996).

Possible Predators – Smallmouth and largemouth bass and sunfish are likely to be the primary predators on round gobies.

Spread – Round gobies are very tolerant of poor water quality and can readily invade new territory. Their long breeding season and the high survival of their eggs (guarded by male gobies) make successful invasions of new habitats quite likely.

Conclusion – The round goby is an ANS that may arrive in Missouri in the next several years.

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Round Goby - Risk Assessment

Q. What is the possibility of the round goby reaching Missouri?
A. High – very certain

The round goby has already reached the Illinois River and is about to reach the Mississippi River. From there, it has access to all of our north and east flowing Ozark waterways.

Q. What is the probability of the round goby surviving in transit to Missouri?
A. High – very certain

The round goby can survive poor water quality such as that found in the Illinois River.

Q. Is it likely to establish and maintain viable populations where introduced?

A. High – very certain

The aggressive nature of the round goby makes it very certain that it will thrive in Missouri.

Q. What is the likelihood that it will spread from areas which are originally colonized?
A. High – very certain

Initially, the round goby will have access to streams and rivers that are tributary to the Missouri and Mississippi rivers. The southern flowing Ozark rivers will have to be reached by migration upstream from Arkansas.

Q. What is the likely economic effect if round gobies become established?
A. Medium – moderately certain

Long term effects on sportfish are tied to goby predation on eggs in nests left unguarded as a result of the males being caught by anglers.

Q. What are the likely environmental effects?
A. High – very certain

Round gobies could negatively affect darter, sculpin and native mussel populations. As egg and juvenile predators, round gobies can have a serious impact on sport fish populations.

Q. What are the likely political effects?
A. High – very certain

Any negative affects on sport fish populations will likely create negative political consequences.

Conclusion – The round goby is a potential ANS with a high probability of invading Missouri in the next few years.

Whirling Disease

Scientific Name – *Myxobolus cerebralis*

Size and Lifespan - *Myxobolus cerebralis* spores are 8-10 μm in diameter and can be found in the cartilage tissues of salmonids.

Reproduction – Spores of *M. cerebralis* are released into the aquatic environment when infected fish die and decompose or are consumed by predators or scavengers. The myxosporean-type spores are ingested by worms in whose gut epithelium the next phase develops. Transformation into the actinosporean *Triactinomyxon*, the infective stage to fish, takes about 3.5 months at 12.5° C, after which infected worms release numerous mature forms into the water for several weeks. The *Triactinomyxon* spores are much larger. The *Triactinomyxon* stage enters susceptible fish through the epithelial cells of the skin, fins, buccal cavity (particularly at the base of the gills), upper esophagus,

and lining of the digestive tract. Transformation into *M. cerebralis* spores then takes about 2.6 months at a water temperature of 12.5° C.

Distribution – Native to central Europe and northern Asia, *M. cerebralis* was introduced into North American waters in the late 1950s. Currently, it is found in 22 states, in several European countries, South Africa, and New Zealand.

Food Habits – Parasitic on tubifex worms initially and in the later life cycle on salmonids.

Habitat Preferences – Cold water streams.

Spread – Infected fish and fish parts are the primary vector for transmitting whirling disease. It may also be transmitted by birds and it is possible fishermen could carry the disease on fishing equipment. However, live infected fish are the main vector for the spread of the disease.

Conclusion – Whirling disease may arrive in Missouri by anglers bringing back infected fish parts or on gear used in infected waters.

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Whirling Disease - Risk Assessment

Q. What is the possibility of the whirling disease reaching Missouri?
A. Medium – moderately certain

Whirling disease is prominent in Montana, Wyoming and Colorado, all places that Missouri anglers frequently fish for salmonids.

Q. What is the probability of the whirling disease surviving in transit to Missouri?
A. High – very certain

The parasite that causes whirling disease could easily survive in fish parts, the mud on waders, or on gear that remains moist.

Q. Is it likely to infect salmonid populations should it be introduced into a Missouri cold water stream?
A. High – very certain

As long as the tubifex intermediate host worm is present, *Myxobolus cerebralis* would thrive in Missouri's cold water trout streams.

Q. What is the likelihood that it will spread from areas which are originally colonized?
A. High – very certain

Once established in Missouri, the *Myxobolus cerebralis* spores would likely be spread on anglers' gear or by anglers transporting fish or fish parts from one stream to another.

Q. What is the likely economic effect if whirling disease becomes established?
A. High – moderately certain

The detrimental effects on Missouri trout populations would have a severe economic impact on trout sport fishing and on related businesses that are supported by the fishery.

Q. What are the likely environmental effects?
A. High – very certain

Trout streams with infected salmonids would require intensive management and could result in losing the entire cold-water fishery.

Q. What are the likely political effects?
A. High – very certain

Any negative affects on the popular trout fishery will likely create negative political consequences.

Conclusion – Whirling disease is a serious problem in many states and has the potential of invading Missouri.

Viral Hemorrhagic Septicemia

Scientific Name – (*Novirhabdovirus* sp.)

Size and Lifespan – The incubation period varies with water temperature. Between 1°C (34°F) and 12°C (54°F), the incubation period for European freshwater VHSV isolates is 1 to 2 weeks at warmer temperatures and 3 to 4 weeks at colder temperatures. Pacific herring infected experimentally with a marine isolate began to die after 4 to 6 days.

Reproduction – Typically, VHSv replicates at temperatures from 2 C to 15 C with the most activity between 6 to 9 C. Thus, the virus is more active in colder water (< 15 C) which is why mortalities are often seen in the spring.

Distribution – The virus has been known in Europe for decades and has been present in the U.S. on both the Pacific and Atlantic coasts. In the Great Lakes region it has been spreading westward and there is a high likelihood that it will be found the Mississippi River or other inland lakes in the Midwest in coming years.

Habitat Preferences – VHSv thrives in cool water less than 15 C.

Spread – If anglers and boaters decide not to comply with the regulations in the region and move infected fish or water, the situation and distribution of the virus could rapidly change. Anglers and/or recreational boaters are the likely mechanism in which VHSv moved into inland waters in the Great Lakes region.

Conclusion – VHS is a contagious fish virus that has caused fish kills in the Great Lakes and in inland lakes in Wisconsin, Michigan and Ohio. It presents a serious threat to sport fish in Missouri. Regulations should be investigated to restrict the movement of fish, bait and water between states and within Missouri.

Viral Hemorrhagic Septicemia - Risk Assessment

Q. What is the possibility of the VHS reaching Missouri?
A. High – very certain

VHS has already been transferred from the Great Lakes to several inland lakes in the Great Lakes area. It seems to be moving west and it will most likely arrive in the bilge water or bait bucket of a recreational boater.

Q. What is the probability of VHS surviving in transit to Missouri?
A. High – very certain

The virus can survive in residual water, bait buckets, or live fish transported to Missouri.

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – very certain

VHS can infect at least 50 different fish species and is impossible to control once it infects a natural fish community.
Q. What is the likelihood that it will spread from areas which are originally colonized?
A. High – very certain

Just as zebra mussels have been spread throughout the US, VHS will likely be spread by a variety of pathways through recreational boater activities.

Q. What is the likely economic effect if VHS infects Missouri's fish populations?
A. High – moderately certain

VHS has been known to cause major fish kills. Any loss of larger sport fish will certainly affect fishing pressure and the businesses that cater to anglers.

Q. What are the likely environmental effects?
A. High – very certain

Regulations will need to be implemented to try to contain VHS in infected waters. VHS could devastate fish populations in Missouri's streams and reservoirs

Q. What are the likely political effects?
A. High – very certain

Any negative affects on sportfish populations will likely create negative political consequences.

Conclusion – VHS a very serious pathogen with the potential to invade Missouri waters in the next few years.

Didymo

Scientific Name – *Didymosphenia geminata* is a larger freshwater diatom (Kilroy, 2004). It can form massive blooms on the bottom of streams, rivers, and rarely in lakes. It is both epilithic (attaching to stones) and epiphytic (attaching to plants) (Cleve, 1894-1896; Kilroy, 2004), attaching itself by stalks, forming a thick brown layer that smothers rocks, submerged plants and other materials.

Size and Lifespan – D. geminata is made up of cells that cannot be seen with the naked eye until large colonies form. It only needs a single cell to be transported for the algae to spread. These cells are distinguished by their large, triundulate frustule, shaped like a curved bottle, and prominent striae (regular lines of holes starting at the centre line of the valve faces) which are radially arranged and variable in length at the centre (Kilroy, 2004).

Reproduction – *Didymosphenia geminata* populations, like those of other diatoms, grow by vegetative cell division. The two valves of the cell each form a new valve which fits inside the original one, thus causing a gradual average reduction in cell size in a population (Round *et al*., 1990; in Kilroy, 2004). Each branch point in the stalk represents a vegetative cell division. Most diatoms also undergo sexual reproduction at some stage, which restores the size of the cells to their maximum (Kilroy, 2004).

Distribution – *D. geminata* is native to northern Europe and northern North America. It is assumed to be indigenous in Norway, Scotland, Ireland, Sweden, Finland, France, Spain, Switzerland and Vancouver Island (Kilroy, 2004).

Food Habits – *D. geminata* is a primary producer.

Habitat Preferences – *D. geminata was* historically found in cool, oligotrophic waters of northern Europe and northern North America. Since the mid-1980s, it has begun to take on the characteristics of an invasive species in both its native range and introduced regions.

Spread – *D. geminata* most likely is spread via human assisted means, for example on waders, fishing equipment, boats, etc.

Conclusion – D. gemonata is found in Arkansas near the Missouri border. It is an invasive with detrimental impacts that will affect the economy, aquatic life, and recreation of infested areas.

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Didymo - Risk Assessment

Q. What is the possibility of didymo reaching Missouri?
A. High – very certain

Didymo has inhabited streams near the Missouri border in Arkansas and will likely be transported into Missouri's cold-water streams by human recreational activities.

Q. What is the probability of didymo surviving in transit to Missouri?
A. High – very certain

Unfortunately, didymo is present downstream from two White River reservoirs in Arkansas, which would only require it to be transported a few miles to reach Missouri waters.

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – very certain

Missouri's cold-water streams provide appropriate habitat for didymo to thrive.
Q. What is the likelihood that it will spread from areas which are originally colonized?
A. High – very certain

Once in a Missouri stream, it is likely that anglers would transfer didymo to other streams near the initial infestation.

Q. What is the likely economic effect if didymo become established?
A. Medium – moderately certain

Severe infestations of didymo would limit the trout fishing area and possibly affect invertebrate production. Loss or reduction of the popular trout fishery would have drastic effects on businesses that support trout anglers.

Q. What are the likely environmental effects?
A. High – very certain

Didymo forms long stalks and can smother shallow stream areas. It may negatively affect invertebrate production and other species in the aquatic community.

Q. What are the likely political effects?
A. High – very certain

Any negative affects on sportfish populations or the aesthetics of Missouri's Ozark streams will likely create negative political consequences.

Conclusion – Didymo is an ANS with a high probability of invading Missouri in the next few years.

Spiny and Fishhook Water Fleas

Scientific Name – *Bythotrephes longimanus* and *Cercopagis pengoi*

Size and Lifespan – Spiny and fishhook water fleas are predatory cladoceran species that feed on other zooplankton. Adult water fleas measure around 1cm in length and are much larger than most zooplankton species native to the Great Lakes. They are characterized by a long caudal tail spine that is barbed and makes up over half the animals body. Longer tail spines with a characteristic 'kink" are associated with the parthenogenically reproduced individuals.

Reproduction – These water fleas are able to have a remarkable influence on the biological communities of the Great Lakes, largely because of their rapid reproduction rate. Most of the time, females exhibit a rapid and unusual method of reproduction known as parthenogenesis, or asexual reproduction. By this method, females produce from one to ten eggs that are able to develop into new females without mating or fertilization. The new females are genetic replicas, or clones, of the mother. During the summer, when the surface water of the lake is warm, water fleas can produce a new generation by parthenogenesis in less than two weeks. Declining environmental quality can be sensed by adult females, who respond by producing male rather than female offspring. These males are able to mate with surviving females, producing resting eggs. The eggs are later released and fall to the lake bottom where they can survive the cold winter. In spring or early summer, these eggs hatch into juvenile females that begin parthenogenic reproduction again.

Distribution – Natives of Great Britain and northern Europe east to the Caspian Sea, these animals were first found in Lake Huron. They were probably imported in the ballast water of a trans-oceanic freighter. Since then, populations have exploded and the animals can now be found throughout the Great Lakes and in some inland lakes.

Food Habits – These water fleas are predators that eat smaller herbivorous Crustacea, including the common zooplankton, *Daphnia. Daphnia*, however, are also an important food item for small, juvenile fish. Thus water fleas compete directly with young fish for food.

Habitat Preferences – Spiny and fishhook water fleas naturally occur in fresh and brackish waters. They prefer to inhabit the pelagic zone of lakes with temperatures between 8°C and 29°C.

Possible Predators – Although these water fleas can fall prey to fish, their spines seems to frustrate most small fish, which tend to experience great difficulty swallowing the animals. In Lake Michigan, spiny and fishhook water fleas can rarely be found in stomachs of fish less than 5 centimeters (2 inches) in length, although fish of that size avidly consume *Daphnia* when that food item is available. There are indications that the growth rates and survival of these young fish may be adversely affected by the presence of these water fleas in the ecosystem, owing to competition for food. In general, the more abundant spiny and fishhook water fleas become, the less food will remain available for juvenile fish.

Spread – Since both creatures are very small and are only noticeable when clumping together, there is a significant chance that they will spread to other inland waters via recreational boats and equipment exposed to infested waters.

Conclusion – The spiny and fishhook water fleas have spread to inland lakes near the Great Lakes and possibly could arrive in Missouri in the next several years.

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Spiny and Fishhook Water Fleas - Risk Assessment

Q. What is the possibility of spiny or fishhook water fleas reaching Missouri?
A. Medium – moderately certain

These invasive water fleas have spread throughout much of the Great Lakes region including some inland lakes. It is possible that they could arrive in water transferred from infested waters.

Q. What is the probability of invasive water fleas surviving in transit to Missouri?
A. High – very certain

It is likely that these water fleas could survive in boats or other water transfers from infested water in the Great Lakes region.

Q. Is it likely to establish and maintain viable populations where introduced?
A. High – moderately certain

These water fleas appear to do well in cooler conditions. It is unknown how invasive they would be in Missouri's warmer reservoir water temperatures.

Q. What is the likelihood that it will spread from areas which are originally colonized?
A. High – very certain

Once established in Missouri, it is inevitable that these water fleas would be spread to other Missouri waters through boating and other recreational activities.

Q. What is the likely economic effect if invasive water fleas become established?
A. Medium – moderately certain

These invasive water fleas could negatively affect juvenile fish survival and cause a nuisance to anglers.

Q. What are the likely environmental effects?
A. Medium – moderately certain

Studies indicate spiny water fleas adversely affect the growth rates and survival of young fish, due to the competition for food and it is expected that the fishhook water flea will have the same affect.

Q. What are the likely political effects?
A. Medium – moderately certain

Any negative affects on sport fish populations will likely create negative political consequences.

Conclusion – The spiny and fishhook water fleas are potential ANS with a high probability of invading Missouri in the next few years.

APPENDIX E

IMPLEMENTATION SCHEDULE FOR

ANS MANAGEMENT GOALS AND OBJECTIVES

Goal I. Inform and educate the bait industry, the aquarium and aquaculture industry, the boating industry and the public to enlist participation and support for halting the introduction and spread of ANS.

Action #	Description	Implement. Agency	Coop Agencies	Fund Source	Recent Efforts	Planned Efforts ($1,000's/FTE's)					Status
						FY08	FY09	FY10	FY11	FY12	
IA	**Raise public awareness of ANS issues in general, and generate widespread public support for efforts to prevent, control, and eradicate ANS**										
IA1	Post MO ANS mgt. plan on MDC web page.	MDC		MDC		1.5/0.08					NI
IA2	Create and post ANS web content on the MDC web page.	MDC		MDC		3/0.2	3/0.02	3/0.02	3/0.02	3/0.02	NI
IA3	Link MDC ANS info to regional and national ANS web pages	MDC	FWS	MDC		1/0.05	0.5/0.02	0.5/0.02	0.5/0.02	0.5/0.02	NI
IA4	Link MDC ANS web page to Dept. Ag noxious weed web page.	MDC	MDA	MDC		1/0.05	0.5/0.02	0.5/0.02	0.5/0.02	0.5/0.02	NI
IA5	Publish two ANS articles in *Conservationist* magazine	MDC		MDC		1/0.01	1/0.01	1/0.01	1/0.01	1/0.01	NI/A
IA6	Broadcast two show segments about ANS on *Missouri Outdoors* TV show.	MDC		MDC			10/0.2	10/0.2	10/0.2	10/0.2	NI/A
IA7	Develop permanent ANS displays for MDC Nature Centers and portable displays for other events	MDC		MDC		10/0.4					
IA8	Amend K-12 curricula to include info re ANS and their threats.	MDC		MDC		5/0.1	5/0.1	10/0.1	10/0.2	10/0.1	NI/A
IA9	Include ANS info in signs, *Fishing Prospects* and	MDC		MDC		0.5/0.005	0.5/0.005	0.5/0.005	0.5/0.005	0.5/0.005	NI/A

	other publications										
IB	**Target stakeholders, including Stream Teams, commercial and recreational anglers, recreational boaters, shipping/barge industry groups, aquaculturists, aquarists, marina owners, and bait shop owners, with informational efforts about the threats proposed by ANS. Cultivate their cooperation and participation in management efforts directed at preventing, minimizing or eliminating ANS effects. Informational efforts should emphasize the potential harm to the particular resource of interest to the stakeholder, and specific actions the stakeholder can take to minimize ANS effects.**										
IB1	Link the Missouri Stream Teams web page to the MDC public web page about ANS	MDC		MDC		1.5/0.08					NI
IB2	Include information on ANS in *Missouri Fishing Prospects*	MDC		MDC		0.5/0.005	0.5/0.005	0.5/0.005	0.5/0.005	0.5/0.005	NI/A
IB3	Create brochures for fairs, nature centers, boat/tackle shows, and MDC offices.	MDC		MDC		10/0.2	10/0.2	10/0.1	5/0.1	5/0.005	A
IB4	Create and post signs at public access sites and private marinas.	MDC		MDC		5/0.05	5/0.05	3/0.05	3/0.05	3/0.05	A
IB5	Provide ANS info to Boat owners.	MDC	DPS WP	MDC		10/0.02	10/0	10/0	10/0	10/0	NI/A
IB6	Provide ANS info with new canoes & boats.	MDC		MDC		5/.02	5/0	5/0	5/0	5/0	NI/A
IB7	Provide ANS info with bait bucket & tackle sales.	MDC		MDC		10/0.02	10/0	10/0	10/0	10/0	NI/A
IB8	Present annual ANS updates at Cons. Federation MO meeting.	MDC		MDC		0.5/0.02	0.5/0.02	0.5/0.02	0.5/0.02	0.5/0.02	NI/A
IB9	Provide opportunities for public input regarding ANS and MDC's efforts	MDC		MDC		0.5/0.02	0.5/0.02	0.5/0.02	0.5/0.02	0.5/0.02	NI/A
IC	Inform conservation professionals about ANS and assist them in their efforts to inform stakeholders and the public about ANS										
IC1	Provide	MDC		MDC		1/0.02	1/0.02	1/0.02	1/0.02	1/0.02	NI/A

	professional development opportunities for MDC employees about ANS										
IC2	Create multi-media shows for use at public and private meetings	MDC		MDC		2/0.1					NI
IC3	Educate DNR & MDA employees about ANS and their threats	MDC	MDA MDNR	MDC		0.5/0.02	0.5/0.02	0.5/0.02	0.5/0.02	0.5/0.02	NI/A
IC4	Evaluate the effectiveness of informational events	MDC		MDC		0.5/0.02	0.5/0.02	0.5/0.02	0.5/0.02	0.5/0.02	NI/A
ID	**Participate in the ANS National Marketing Strategy developed by the Association of Fish and Wildlife Agencies (AFWA)**										
ID1	Develop ANS marketing plan with AFWA grant	MDC	AFWA	AFWA		1/0.01	1/0.01	1/0.01	1/0.01	1/0.01	NI/A
ID2	Implement the ANS marketing plan	MDC	AFWA	AFWA		1/0.01	1/0.01	1/0.01	1/0.01	1/0.01	NI/A

MDA=Missouri Department of Agriculture
MDNR=Missouri Department of Natural Resources
FWS=US Fish and Wildlife Service
AFWA=Association of Fish and Wildlife Agencies
DPS = Department of Public Safety
WP=Water Patrol
MDC = Missouri Department of Conservation

Status: A = Annual
NI = New Initiative

Goal II. Collaborate in the development and enforcement of state and national legislation and other regulations designed to prevent ANS introduction into state waters.

Action #	Description	Implement. Agency	Coop. Agencies	Fund Source	Recent Efforts	Planned Efforts($1,000's/FTE's)					Status
						FY08	FY09	FY10	FY11	FY12	
IIA	**Coordinate and develop a comprehensive state legislative and regulatory program aimed at preventing the introduction and spread of ANS into un-infested waters of the state.**										
IIA1	Review & update *Approved Aquatic Species List.*	MDC	MDA MDNR	MDC		1/0.01	1/0.01	1/0.01	1/0.01	1/0.01	A
IIA2	Review state laws & regulations & make recommendations for changes.	MDC	MDA MDNR MOAG	MDC		2/0.02	2/0.02	2/0.02	2/0.02	2/0.02	NI/A
IIA3	Participate in Missouri Aquaculture Coordinating Council meetings.	MDC	MDA	MDC		1/0.01	1/0.01	1/0.01	1/0.01	1/0.01	A
IIA4	Elevate the penalty for release of aquatic nuisance species beyond a Class C misdemeanor	MDC	MDA	MDC		2/0.01					NI
IIA5	Establish a "Prohibited Species List" in the *Wildlife Code of Missouri*	MDC		MDC		2/0/01					NI
IIB	**Participate in development of a Midwest regional ANS policy to prevent new invasions in the Missouri and Mississippi rivers**										
IIB1	Maintain a presence in MICRA & participate in ANS policy development.	MDC	FWS & other states	MDC		1/0.01	1/0.01	1/0.01	1/0.01	1/0.01	A
IIB2	Participate in Mississippi River Basin Panel of ANS Task Force	MDC	FWS & other states	MDC		1/0.01	1/0.01	1/0.01	1/0.01	1/0.01	NI/A

MDA = Missouri Department of Agriculture
FWS = US Fish and Wildlife Service
MOAG=Missouri Attorney General
MDNR=Missouri Department of Natural Resources
MDC = Missouri Department of Conservation

Status: A=Annual
NI=New Initiative

Goal III. Monitor the occurrence and distribution of ANS in Missouri waters and conduct research into ways to restrict their spread.

Action #	Description	Implement. Agency	Coop. Agencies	Fund Source	Recent Efforts	Planned Efforts ($1,000's/FTE's)					Status
						FY08	FY09	FY10	FY11	FY12	
IIIA	**Identify current distribution of ANS in Missouri waters**										
IIIA1	Organize and encourage Department field staff, interested volunteers and other stakeholders to monitor and report the occurrences of ANS. Provide appropriate identification materials for each ANS to be monitored.	MDC	MDC MDA Vols FWS USGS	MDC FWS USGS		20/1	20/1	20/1	20/1	20/1	NI/A
IIIA2	Update ANS distributions as additional info becomes available. Prepare annual summary report.	MDC	MDC MDA Vols	MDC FWS		2/0.1	2/0.1	2/0.1	2/0.1	2/0.1	NI/A
IIIA3	Recommend additional monitoring, or new techniques, as necessary.	MDC	MDC MDA FWS	MDC FWS		1/0.1	1/0.1	1/0.1	1/0.1	1/0.1	NI/A
IIIA4	Development of an early detection/rapid response system and protocol with partners and stakeholders in Missouri.	MDC	MDC FWS MDA USGS Vols NGO's MDNR Univ WP USCG	MDC FWS MDA USGS Vols NGO's MDNR Univ WP USCG		1/0.1	1/0.1	1/0.1	1/0.1	1/0.1	NI/A
IIIB	Conduct or support research into ANS life history, methods for transport and introduction, and techniques useful for control or elimination										
IIIB1	Conduct a comprehensive review of past and ongoing research on ANS and make recommendations for research in FY12 and FY12-16.	MDC	MDC FWS	MDC FWS		2/0.1				2/0.1	NI
IIIB2	Where possible, develop, fund and implement "action plans" to interrupt paths by which ANS are introduced & spread	MDC	MDC MDA	MDC FWS		35/0.3	35/0.3	35/0.3	35/0.3	35/0.3	NI/A

MDC = Missouri Department of Conservation
MDA = Missouri Department of Agriculture
FWS = US Fish and Wildlife Service
Vols = Volunteers
NGO's = Non-governmental organizations
MDNR = Missouri Department of Natural Resources
Univ = Missouri Colleges and Universities
WP = Water Patrol
USCG=United States Coast Guard

Status: A = Annual
NI = New Initiative

Goal IV. Develop and implement techniques and management actions to abate the harmful effects of ANS on native biological communities.

Action #	Description	Implement. Agency	Coop. Agencies	Fund Source	Recent Efforts	Planned Efforts ($1,000's/FTE's) FY08	FY09	FY010	FY11	FY12	Status
IVA	Develop economical abatement plans for high priority ANS threatening native biological communities										
IVA1	Develop abatement plans using national, regional, and state research and monitoring.	MDC	MDC MDA	MDC FWS		5/0.2	10/0.3	30/0.4	50/0.5	70/0.7	NI/A
IVA2	Maintain or establish adequate reproducing stock of threatened organisms which can be used to restock Missouri waters following elimination or reduction of ANS threats. These actions must be determined to be cost effective.	MDC		MDC FWS		10/0.3	10/0.3	20/0.5	20/0.5	40/0.7	NI/A
IVA3	Secure funding from federal, state, other public, and private interests to implement ANS abatement plans	MDC		MDC FWS Other		2/0.2	2/0.2	2/0.2	2/0.2	2/0.2	NI/A

MDA = Missouri Department of Agriculture
FWS = US Fish and Wildlife Service
MDC = Missouri Department of Conservation
Other = other outside sources of funding

Status: A = Annual

NI = New Initiative

Goal V. Where economically feasible, abate harmful effects of ANS on the socio-economic and health status of Missourians.

Action #	Description	Implement. Agency	Coop. Agencies	Fund Source	Recent Efforts	Planned Efforts ($1,000's/FTE's)					Status
						FY08	FY09	FY10	FY11	FY12	
VA	**Assess effects of high priority ANS on the socio-economic and public health status of Missourians**										
VA1	Evaluate costs and human injury threats associated with high priority ANS invasions.	MDC	MDC MDA MDH	MDC FWS		5/0.2	5/0.2	5/0.2	5/0.2	5/0.2	NI/A
VA2	Prioritize development of abatement plans.	MDC	MDA MDH	MDC FWS		3/0.2	3/0.2	3/0.2	3/0.2	3/0.2	NI/A
VB	**Develop and implement abatement strategies including physical, chemical, and biological control methods which have a reasonable chance of reducing or eliminating target ANS**										
VB1	Support and conduct research investigating potential abatement strategies.	MDC	MDC FWS	MDC FWS		20/0.5	20/0.5	50/0.5	50/0.5	50/0.5	NI/A
VB2	Participate in technology transfer program to distribute research findings and results from implementation of abatement strategies.	MDC	FWS MDC	MDC FWS		5/0.2	5/0.2	5/0.2	5/0.2	5/0.2	NI/A
VB3	Seek approval to implement abatement plans	MDC	MDH Private FWS	MDC MDH FWS		5/0.2	5/0.2	5/0.2	5/0.2	5/0.2	NI/A
VC	**Where feasible, adapt human activities to co-exist with ANS populations where control is impractical or uneconomical**										
VC1	Seek beneficial uses of ANS and convey to the general public.	MDC	MDC FWS Private			5/0.2	5/0.2	5/0.2	5/0.2	5/0.2	NI/A
VC2	Participate in research into how to co-exist with ANS.	MDC	MDA MDH Private	MDC FWS		20/0.2	20/0.2	15/0.2	15/0.2	15/0.2	NI/A
VC3	Promote development of a commercial fishery for Asian carps to provide human and pet food.	MDC	MDA MDED Private	MDC MDA		1/0.10	1/0.10	1/0.10	0.5/0.10	0.5/0.10	NI/A

Private = Non-governmental groups
MDED = Missouri Department of Economic Development
MDH = Missouri Department of Health
MDA=Missouri Department of Agriculture
MDC=Missouri Department of Conservation
FWS = United States Fish & Wildlife Service

APPENDIX F

PUBLIC INPUT SUMMARY

APPENDIX F

PUBLIC INPUT SUMMARY

The Missouri Department of Conservation (MDC) used a variety of avenues to request public input and comment to the draft Aquatic Nuisance Species Management Plan (ANS Plan). Public review, comment, and recommendations are a critical component for all of us to come to a common understanding of this issue and what can be done to slow the spread of ANS. The following is a bulleted summary of what MDC has done to get public input on this draft plan.

- A two page summary (Appendix F, Attachment 1) was provided to the public that participated in one of the eight (8) MDC 2005 Regional Fall Forums.

- The draft ANS plan was available for public review and comment on the MDC public Web site (http://www.mdc.mo.gov) for 3 months.

- ANS plan summaries were mailed to an MDC generated (not comprehensive) list of Missouri pet store owners and Missouri bait shop and bait dealers (Appendix F, Attachment 2 & 3).

- A copy of the draft ANS plan was mailed to several agency partners for review. Comments and recommendations were received from:

  ►Bart Harcroft, Missouri Department of Agriculture
  ►Scott Newsham, US Fish and Wildlife Service
  ►Marilyn Barrett-O'Leary, Southeast Aquatic Resources Partnership

- Presentation specific to the draft ANS plan were provided to the Missouri Aquaculture Coordinating Council, the Missouri Aquaculture Association, and a meeting of Missouri Bait Dealers.

Through this effort, substantive comments were received from agency partners. Minimal comment was received from the general public.

APPENDIX F
Attachment 1

MISSOURI DEPARTMENT OF CONSERVATION

AQUATIC NUISANCE SPECIES MANAGEMENT PLAN

Plan Summary:

Missouri's landscape includes a wide array of aquatic resources. Included are: 17 large reservoirs totaling more than 250,000 surface acres; approximately 500,000 smaller public and private lakes and ponds; approximately 17,000 miles of permanently flowing streams and rivers and another 39,000 miles of intermittent headwater streams. These resources are threatened by migration of non-native aquatic species into open river systems, and by their accidental or intentional release into other public and private waters. The biological and socio-economic effect of each of these introduced species has not yet been fully determined, however, some are known to be significant.

An estimated 50,000 species have been introduced into the United States in the past 200 years. Many, like corn, wheat, rice, other crops, and cattle, poultry, and other livestock, provide more than 98% of our food and can be valued at approximately $800 billion annually. Nationally, however, the damage from other non-native species, and the cost of their control, has been estimated at $138 billion annually (Pimental et al. 2000). These funds dedicated to the prevention, control, and mitigation of the effects of invasive species could have been used for other purposes. When funding from fish and wildlife agency budgets is assigned to the prevention, control, and management of invasive species, important research and management of native ecosystems suffers from the diversion. Public recreational benefits also suffer.

Not every non-native species in Missouri waters qualifies as an Aquatic Nuisance Species (ANS). Aquatic nuisance species are defined as follows:

"Aquatic nuisance species" (ANS) - non-native species which threaten the diversity or abundance of native aquatic species or the ecological stability of infected waters, or commercial, agricultural, aquacultural, or recreational activities dependent on such waters.

Twelve (12) ANS are already found in Missouri waters and 14 additional ANS may arrive in the near future. Examples of ANS include purple loosestrife, zebra mussels and silver carp. In many cases, these species are actively expanding their ranges and compounding their effects on native ecosystems. The connection between the Great Lakes and the Missouri and Mississippi rivers via the Illinois River is particularly

troubling because it creates a pathway for ANS to Missouri waters from international sources.

Even aquatic species that are native within the political boundaries of Missouri can also become aquatic nuisance species if they are moved into drainages where they are not native. Such “inter-basin” transfers of species can be just as damaging to native ecosystems as introductions of species from other continents.

Failure to address the spread and effects of aquatic nuisance species poses grave economic consequences to Missouri. At risk are entire ecosystems and the benefits they provide. Fishing alone accounts for approximately $758 million in total expenditures each year, and ANS directly threaten this and other vital economic activity.

Missouri’s ANS Management Plan is designed to meet the requirements of Section 1204 (a) of the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990 as reauthorized and amended by the National Invasive Species Act (NISA) of 1996. The Plan will provide a framework for how future efforts regarding prevention, control, and mitigation of the effects of ANS in Missouri can be organized. It is designed to address ANS invasions at several different stages including:

- identifying and implementing all possible actions necessary to stop the introduction of new ANS from any area outside Missouri,
- developing methods to detect and to stop the spread of ANS into new habitats within Missouri,
- minimizing the effects of ANS on native biological communities where introductions have already occurred, and
- abating the socio-economic and public health concerns that might arise as a result of ANS.

The Aquatic Nuisance Species Plan has been written in a format that can be used to apply for federal grants to help pay for actions which will prevent the invasion or spread of ANS and the problems they are likely to create.

The draft Aquatic Nuisance Species Management Plan is available for review and comment at: www.mdc.mo.gov/fish/ or by writing the Department at P.O. Box 180, Jefferson City, MO 65102-0180

APPENDIX F
Attachment 2

August 23, 2005

Dear Bait Shop Owner:

Managing Missouri's fish and aquatic resources is the job of the Department of Conservation's Fisheries Division. One of the largest threats to these resources is the increasing number of invasive aquatic nuisance species. Such species find their way to our waters through a variety of sources including the improper disposal of bait, transport on boats or fishing equipment, release of unwanted pets by their owners or simply by moving through interstate waters to Missouri.

The bait industry is a key partner with the Department in our efforts to prevent the spread and reduce the prevalence of aquatic nuisance species. For that reason, I want to let you know that we have drafted an aquatic nuisance species management plan and a summary of that draft plan is enclosed with this letter. Please have a look at the summary and feel free to consult our website or write us for a copy of the entire plan. Any comments or suggestions you might have for improvement would be appreciated. Please forward any comments to us by October 1, 2005.

Thank you for your help in conserving Missouri's aquatic resources.

Sincerely,

Steve Eder
Fisheries Division Administrator

APPENDIX F
Attachment 3

August 23, 2005

Dear Pet Store Owner:

Managing Missouri's aquatic resources is the job of the Department of Conservation's Fisheries Division. One of the largest threats to these resources is the increasing number of invasive aquatic nuisance species. Such species find their way to our waters through a variety of sources, including the release of unwanted pets by their owners, improper disposal of bait, transport on boats or fishing equipment or simply by moving through interstate waters to Missouri.

The pet industry is a key partner with the Department in our efforts to prevent the spread and reduce the prevalence of aquatic nuisance species. For that reason, I want to let you know that we have drafted an aquatic nuisance species management plan and a summary of that plan is enclosed with this letter. Please have a look at the summary and feel free to consult our website or write us for a copy of the entire plan. Any comments or suggestions you might have for improvement are appreciated. Please forward any comments to us by October 1, 2005.

Thank you for your help in conserving Missouri's aquatic resources.

Sincerely,

Steve Eder
Fisheries Division Administrator